New Possibilities of Intelligent Crisis Management by Large Multimedia Artifacts Prebuffering

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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. Our goal is to complement the data networking capabilities of RF wireless LANs with accurate user location and tracking capabilities for user needed data prebuffering. We created a location based system enhancement for locating and tracking users of our control system inside the buildings. User location is used for data prebuffering and pushing information from server to user's PDA. All server data is saved as artifacts (together) with its position information in building. The accessing of prebuffered data on mobile device can highly improve response time needed to view large multimedia data. This fact is very important for new possibilities of intelligent crisis management. Rescuers can handle with new types of artifacts which can increase rescue possibilities.

Keywords: Crisis Management, Prebuffering, Localization, PDPT Framework, Wi-Fi, 802.11b, MDA, Response Time, SQL Server Mobile.

1 Introduction

The usage of various mobile wireless technologies and mobile embedded devices has been increased 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 that provide more or less the same functionality as their desktop application equivalents. 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 different. Context-awareness concepts can be found as basic principles in a long-term strategic research for mobile and wireless systems such as formulated in [1]. The majority of context-aware computing to date has been restricted to location-aware computing for mobile applications (location-based services). However, position or location information is a relatively simple form of contextual information. To name a few other indicators of context awareness that make up the parametric context space: identity, spatial information (location, speed), environmental information (temperature), resources that are nearby (accessible devices, hosts), availability of

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resources (battery, display, network, bandwidth), physiological measurements (blood pressure, heart rate), activity (walking, running), schedules and agenda settings.

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 prebuffering. This property we use as an information ground for extension of information system. The remainder of this paper describes the conceptual and technical details.

2 Basic Concepts and Technologies of User Localization

Among the many location systems proposed in the literature, the most effective are those based on radio location techniques that exploit measurements of physical quantities related to radio signals travelling between the mobile terminal (MT) and a given set of transceivers whose location is known, e.g., base stations (BSs) and/or navigation satellites. Radio signal measurements are typically the received signal strength (RSS), the angle of arrival (AOA), the time of arrival (TOA), and the time difference of arrival (TDOA).

Radio location techniques are generally classified into two categories: modified and unmodified handset solutions. The former techniques require some adjustment to be implemented in existing handsets, while the latter ones only need modification at the BS sites or switching centers. It is apparent that installing a global positioning system (GPS) receiver on each handset seems to be the most straightforward positioning approach. However, additional hardware and required computational burden reduce the power efficiency and increase the weight, size, and cost of the MTs. Moreover, the GPS receiver needs the simultaneous visibility of at least four satellites, which is not guaranteed in indoor and urban environments. To improve reliability and reduce time to position fix, wireless network information can be combined with satellite positioning, as suggested in assisted-GPS (A-GPS) techniques. Nevertheless, the biggest drawback remains the number of modifications required at both the handset and the fixed network infrastructure. Therefore, radio location techniques based on less expensive unmodified terminals represent a promising tradeoff between performance and overall implementation complexity.

2.1 Radio Location Techniques in Wireless Communications Systems

The radiolocation techniques are classified into two main groups on the basis of the number of BSs involved in the estimation process, i.e., one BS or multiple BSs. They can be implemented in any wireless communication system, provided that reliable measurements of the physical quantities related to known signals travelling either from the BSs to the MT (downlink) or from the MT to the BSs (uplink) are available. In the downlink case, location measurements are generally made using a reference signal broadcast by all the BSs with the same power.

RSS Algorithm Requiring More Than One BS

The technique described here call for a minimum number of simultaneously available BSs, which could not be always guaranteed in actual environments wherein the number of signals received at the MT with a sufficient power level may be lower than that required by the location algorithm. RSS positioning algorithm is based on the measurement of the RSS of a known training sequence sent by the MT to NBS different BSs (NBS 2: 3). If the transmit power is known, the distance between a BS and the MT can be estimated using the received power level and a proper mathematical model for the path los s attenuation law. As a signal strength measurement provides a distance estimate, the MT must lie on a circle centered at the BS. By using at least three BSs to resolve ambiguities, the MT position estimation can be identified via a trilangulation technique at the intersection point of the relevant circles. Power control strategies commonly used in wireless cellular systems may, however, hinder the effectiveness of such a technique.

Single-BS Algorithms

Single-BS solutions offer many advantages over multiple BS ones. The coverage by several BSs (i.e., the hearability) is no longer a problem. Finally, the internetwork signaling requirement is significantly reduced. On the other hand, most of these methods are prone to severe performance degradation in NLOS conditions. The cell identification (Cell-ID) technique (as one example) simply identifies the position of the MT with that of the serving BS. While the idea of the Cell-ID is attractive for its simplicity and low implementation costs, its accuracy is inversely proportional to the cell size and could be not adequate for the FCC requirements and the most demanding location services.

2.2 Data Collection, Localization

A key step of the proposed research methodology is a 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 the signal strength (SS) available. SS is reported to 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. Each time the broadcast packet is received the WaveLAN driver extracts the SS information from the WaveLAN firmware. Then it makes the information 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.

The general principle 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 the mobile device knows the position of the stationary device, it also knows that its own position is within a 100-meter range of this location provider. Granularity of location can improve by triangulation of two or several 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. 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 [14].

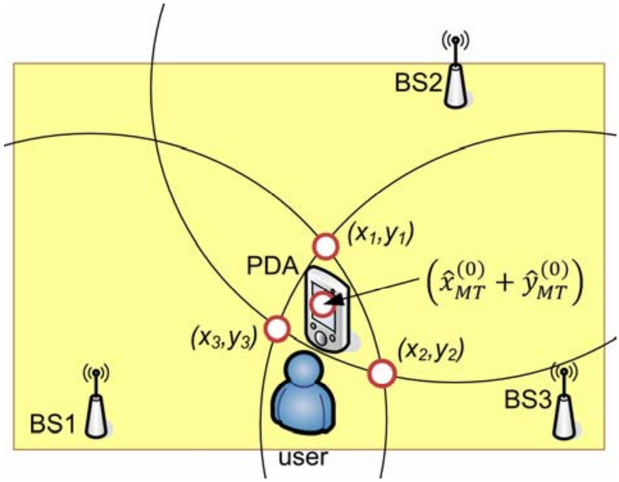

Fig. 1. Localization principle – triangulation

Schema on figure [Fig. 1] describes a localization process. The mobile client gets the WiFi SS of three BSs with some inaccuracy. Circles around the BSs are crossed in red points on figure. The intersection red point (centre of three) is the best computed location of mobile user. The user track is also computed from these measured WiFi intensity level and stored in database for later use.

2.3 Super-Ideal WiFi Signal Strength Equation from Measured Characteristics

The WiFi middleware implements the client's side of location determination mechanism on the Windows Mobile 2005 PocketPC operating system and is part of the PDA client application. The libraries used to manage WiFi middleware are: AccessPoint, AccessPointCollection, Adapter, AdapterCollection, AdapterType, ConnectionStatus, Networking, NetworkType, SignalStrength. Presented libraries are used to manage information about WiFi APs in user PDA nearby. We created special software for scanning user neighborhoods for visible WiFi networks called WiFi Analyzer [Fig. 2].

WiFi Analyzer [13] is a WiFi utility to scan and analyze with PDA for visible WiFi AP. Analyzer show WiFi quality in graph and statistics. Utility allow export measured data to excel. This software allows:

- Display visible WiFi Access Point (802.11b and g standard)
- Analyze visible APs
- Make graph for APs signal measure
- Make statistical data with measured AP signal strength
- Data are updated from 1 to 10 per second
- Insert info about user position to database
- Export option to select data to store in database
- View a graph with signal strength history. (throw Excell)
- Save the measured data to the files on Pocket PC

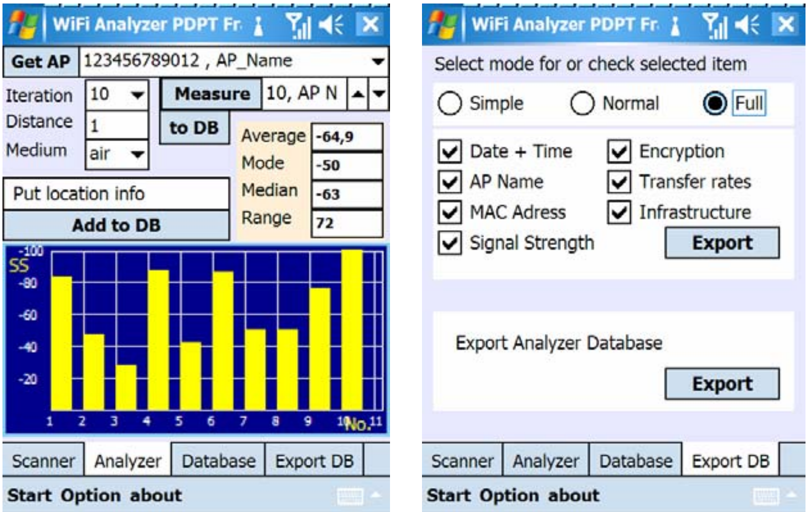

Fig. 2. WiFi Analyzer PDPT Framework – analyzer tab (left) and export DB tab (right)

The WiFi Analyzer software was used to build a database of WiFi APs located in our test environment at campus of Technical University of Ostrava. The campus wireless network is equipped with 32 Cisco AP (December of 2008). Types of these Cisco APs are collect in [Table 1]:

Table 1. Cisco WiFi APs with Transmit Power [mW]

AP Type	*AP* quantities	Transmit Power [mW]			
		50	30	20	10
C1100	24	21	0	2	1
C1130	6	-	6	-	-
C1210	1	1	-	-	-
C1310	1	1	-	-	-

From table summary is evident that 26 APs from 32 APs transmitting with power of 50 mW. We made a simplification to consider only APs with this transmit power. With three APs of them we made a measurements to create a transmit power graph. The SS power was measured by standard PDA device HTC Blueangel to receive a same level of SS as in real case of PDA device usage.

From characteristics at [Fig. 3] is evident the signal strength is present only to 30 meters of distance from base station (this fact is very important for future ideas and real usage because our test environment is not well fitting for use of PDPT Framework).

We used these three characteristics to make a combination of them to get a super-ideal characteristic. Such characteristic need to be compared with ideal theoretic limit

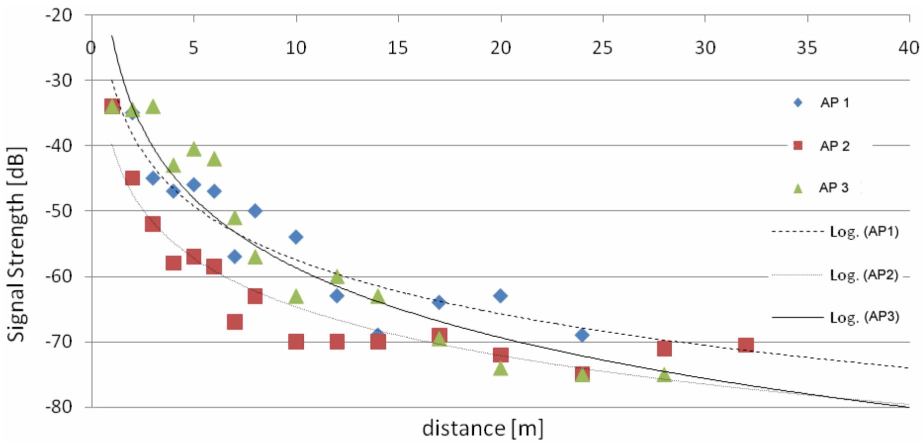

Fig. 3. Signal Strength Graph from three Cisco WiFi APs

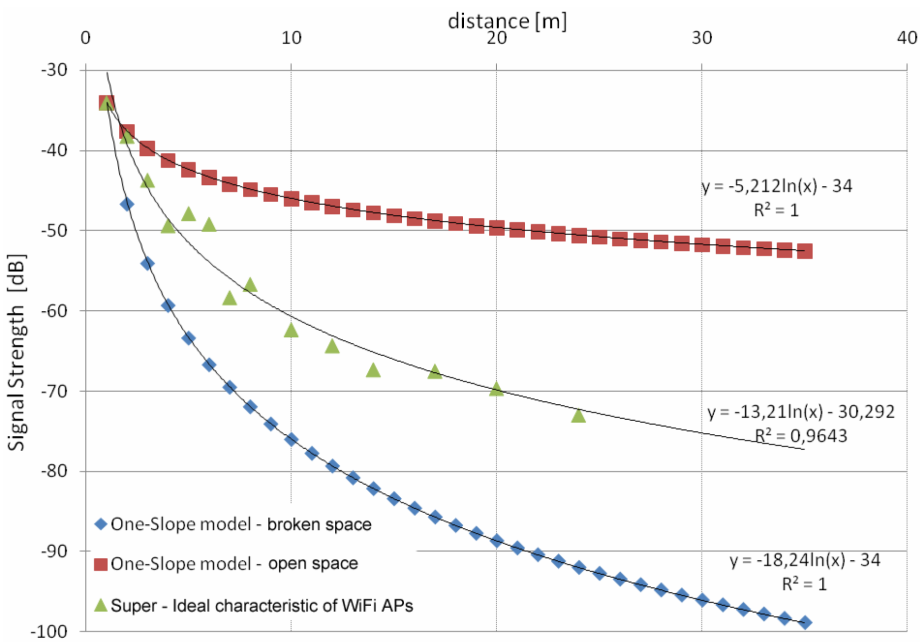

Fig. 4. Real versus Ideal Characteristics of WiFi Signal Strength

characteristics. Equations for computing such characteristics are taken from One-Slope model. See equation (1) for broken space and (2) for open space areas.

$$L(d) = -34 - 42\, log(d) \text{ for } L_1 = -34 \text{ dB and } n\ 4{,}2 \tag{1}$$

$$L(d) = -34 - 12\, log(d) \text{ for } L_1 = -34 \text{ dB and } n\ 1{,}2 \tag{2}$$

Super-Ideal characteristic with two limit theoretic characteristics are in [Fig. 4]. The computed equation for Super-Ideal characteristic is taken as basic equation for PDPT Core to compute the real distance from WiFi SS.

2.4 Predictive Data Push Technology

This part of the project is based on a model of location-aware enhancement, which we have used in created control 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. These techniques form the basis of predictive data push technology (PDPT). PDPT copies data from information server to clients PDA to be helpful when user comes at desired location. The benefit of PDPT consists of 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, because of protocol cost on physical layer (app. 30-40 %). 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 only 80 - 160 kB/s (depends on file size and PDA device).

The second aspect is the size of copied data. Current application records just one set of signal strength measurements at the time (by Locator unit in PDPT Client). By this set of values the actual user position is determined by the PDPT server side. PDPT core responds to location change by selection of the artifact to load to PDPT client buffer. The data transfer speed is widely influenced by the size of these artifacts. For larger artifact size the speed is going down.

Theoretical background and tests were needed to determine an average artifact size. First of all the maximum response time of an application (PDPT Client) for user was needed to be specified. A special book [12] of „Usability Engineering" specified the maximum response time for an application to 10 seconds. During this time the user was focused on the application and was willing to wait for an answer. We 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 transfer speed was from 80 to 160 kB/s the result file size was from 800 to 1600 kB. The next step was an average artifact size definition. We used a sample database of network architecture building plan (Autocad file type), 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 problem is the time, which is needed for displaying them. In case of Autocad file type we measured this time to average 45 seconds. This time consumption is certainly not acceptable, for this reason we are looking for a better solution. We need to use some basic data format, which can be displayed by PDA natively (BMP, JPG, GIF) without any additional striking time consumption. The solution is in format conversion from any to this native (for PDA devices). In case of sound and video format we also recommend using basic data format (wav, mp3, wmv, mpg).

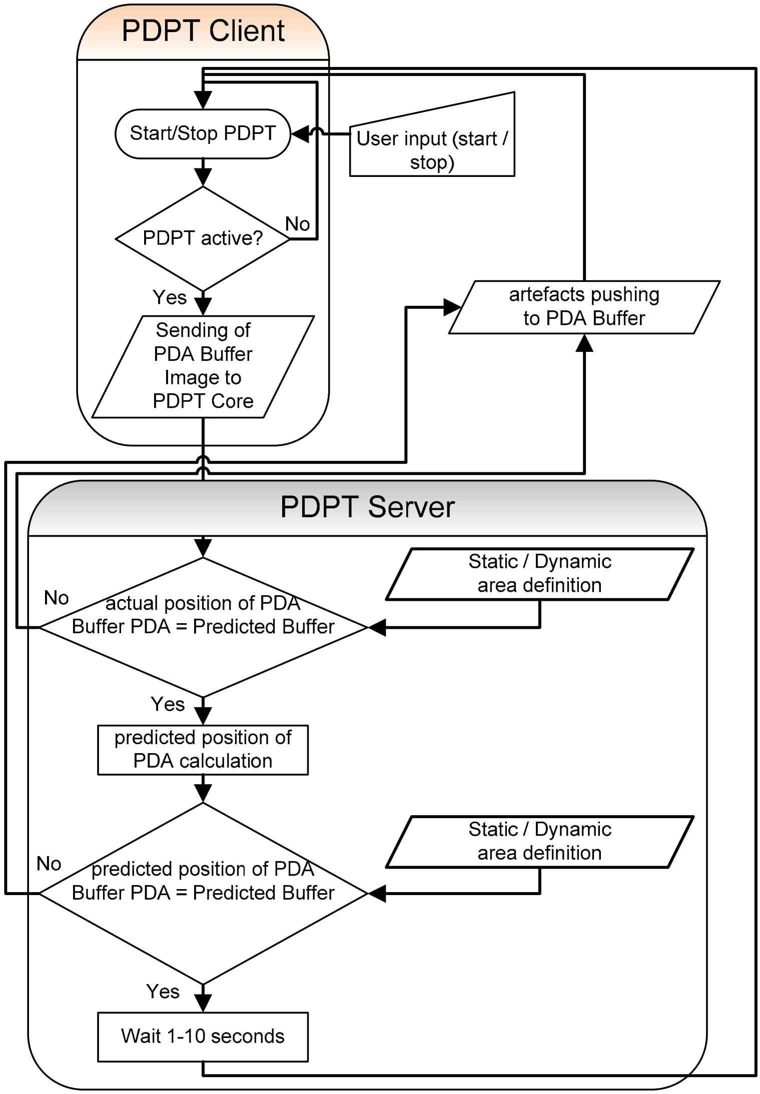

Fig. 5. PDPT Framework – prebuffering architecture

The final result of our 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.

2.5 Framework Design

PDPT framework design is based on the most commonly used server-client architecture. To process data the server has online connection to the control system. Technology data are continually saved to SQL Server database [2] and [4].

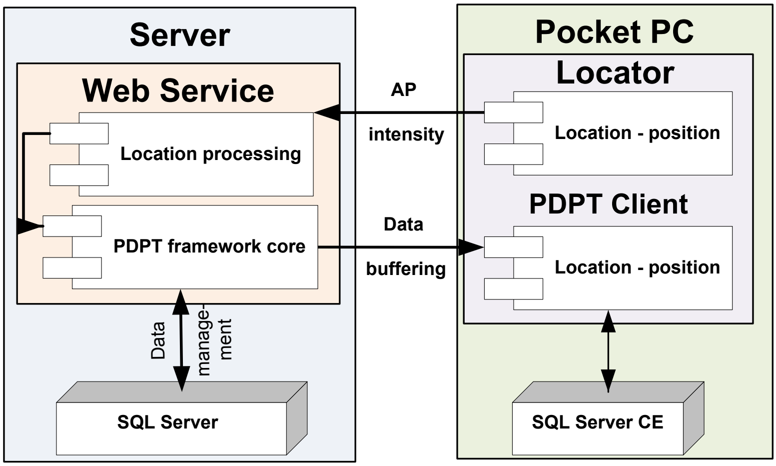

Fig. 6. System architecture – UML design

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 the information about nearby AP's intensity to the framework kernel. The kernel processes this information and makes a decision if or how the 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 the future possible requirements. The PDPT framework server is created as Microsoft web service to handle a bridge between SQL Server and PDPT PDA Clients.

2.6 PDPT Client

For testing and tuning of PDPT Core was created the PDPT Client application. This client realizes classical client to the server side and an extension by PDPT and Locator module. Figure [Fig. 7] shows two screenshots from mobile client. The first one (left) show the table of exist artifacts in database on server. The user can select several artifacts by checking and press the "Load To SQL CE" button to push selected artifacts from server to client. This is the classical way how clients can download the data from server. The second one screenshot shows classical view of data presentation from MS SQL CE database to user (in this case the image of Ethernet network in company area plan). Each process running in a PDPT client is measured in millisecond resolution to provide a feedback from real situation. In first case the time window is in lower right side of screen. In second one the upper right side of screen is occupied.

Tabs PDPT and Locator (see figure [Fig. 8]) presents a way to tune the settings of PDPT Framework. In first case (left screenshot) the user must turn on Locator checkbox which mean the measurement of WiFi signals of nearby APs (time of these operations is measured in Locator Time text window). The info about nearby APs is

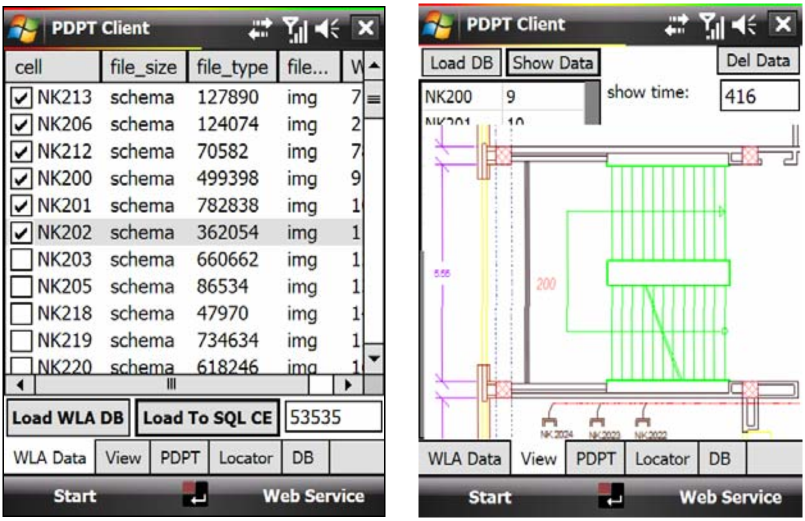

Fig. 7. PDPT Client – Windows Mobile 6.0 application

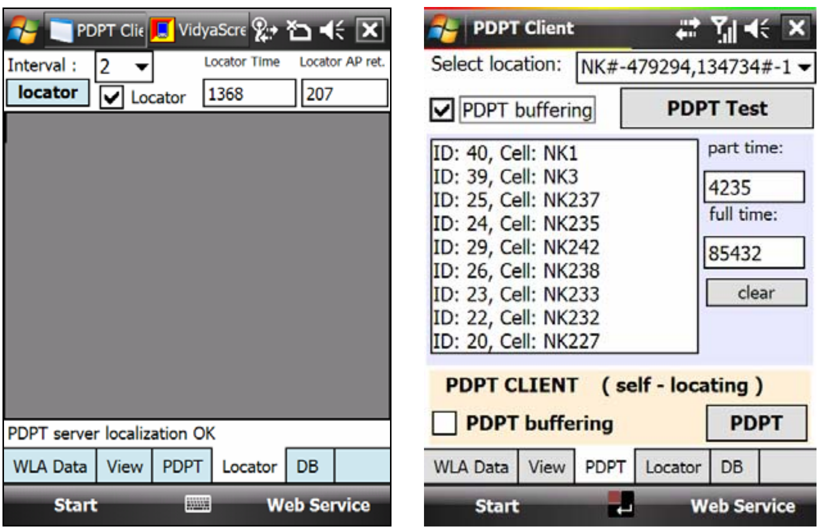

Fig. 8. PDPT Client –Locator and PDPT tabs

send to PDPT server which responds with a number of recognized APs in database (Locator AP ret. Text window). In current case the 7 APs are in user neighborhood, but only 2 APs are recognized by PDPT Server database (info about them is in WLA database). Scanning interval is set to 2 seconds and finally the text "PDPT server localization OK" means the user PDA was localized in environment and is possible to use this position by PDPT Framework core to prebuffer the data to client device. The second case of figure [Fig. 8] is PDPT Client settings tab. The middle section describes the process of prebuffering by logging info. The right side means measure the time of one artifact loading ("part time") and full time of prebuffering.

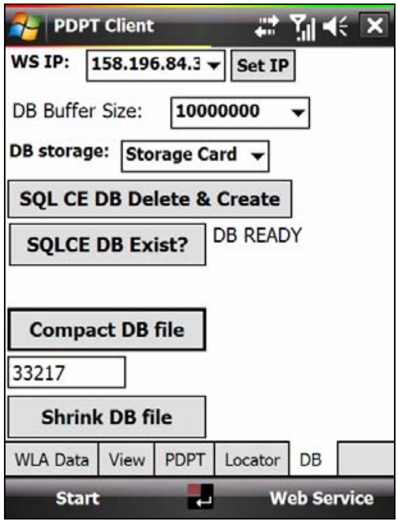

Fig. 9. PDPT Client – Windows Mobile 6.0 application. DB Tab

2.7 PDPT Client – SQL Server CE Database

For managing of database file on PDA device we created small DB manager [Fig. 9]. First *combobox* menu on this tab deal with IP address settings of PDPT server. DB Buffer size follows on second *combobox*. This size is important for maximum space taking by prebuffering database on selected data media. Data medium can be selected on DB Storage *combobox*. For check of database existence the SQLCE DB Exist button must be pressed. In example the db is ready means the database file exists on selected location. If such db file does not exist, we need to execute the SQL CE DB Delete & Create. This buttons can be used for recreating of db file (see program code example).

Example of a C# Program Code – *SQLCE DB Create* button:

```
SqlCeEngine eng = new SqlCeEngine(
                 @"Data Source=\SD_CARD\\DbBuffer.sdf");
eng.CreateDatabase();
SqlCeConnection CEcon = new SqlCeConnection(
                 @"Data Source=\SD_CARD\\DbBuffer.sdf");
CEcon.Open();
string String = "CREATE TABLE buffer("
+ "Date_Time DateTime not null, "
+ "cell nvarchar(50) not null, "
+ "file_type nvarchar(50) not null, "
+ "file_binary image not null, "
+ "file_description nvarchar(50) not null, "
+ "ID bigint not null "
+ ")";
SqlCeCommand CEcmd = new SqlCeCommand(String, CEcon);
CEcmd.CommandType = CommandType.Text;
CEcmd.ExecuteNonQuery();
```

Compact and *Shrink of DB* file means two options of compacting a database by manual way. The time in millisecond is measured in text box between both buttons. Both of these mechanism are used in prebuffering cycles when the large artifact is deleted from database table, because the standard operation of delete order is not include this technique, so the database file is still has occupied space of deleted artifact. This is due to recover possibilities in Microsoft SQL Server CE databases.

3 User Localization in Intelligent Crisis Management

Many people define crisis management as emergency response or business continuity, while other people will only consider the public relations aspect [3]. They are all partially correct, but true crisis management has many facets. It must be thoroughly integrated into the organization's structure and operations. Achieving an effective level of crisis management requires a thorough internal analysis, strategic thinking and sufficient discussion.

Crisis Management is the umbrella term that encompasses all activities involved when an organization prepares for and responds to a significant critical incident. An effective crisis management program should be consistent with the organization's mission and integrate plans such as Emergency Response, Business Continuity, Crisis Communications, Disaster Recovery, Humanitarian Assistance, etc.

Fireman, police and rescue service are very important part of this crisis management. Management and coordination of this people is now practicable by shortwave communication (radio, transmitter), but new mobile communication technologies as PDA's can level up potential and speed of action in crisis situations. As discussed before, we can locate any people with PDA running client software. But how localization of these people can help them? Advantage is in tracking of these people. For example when fireman arrive to crisis place, his PDA will make an interconnection to crisis management system of building which fireman arrive and the software on PDA will guide the fireman by shortest safe way directly to the centre of problem in the crisis building. In this case function, the PDA act as a navigator and it can help people to make a good orientation around unknown building.

Navigating of rescue people is first but not last possibility which PDA and localization can help. The PDPT Framework can manage large multimedia artifacts as described before. Using of such multimedia files allow to access on PDA for example building plans, pictures of strategic points in environments (electricity case, gas pipe, etc.), video of standard function of machinery or furnishings, etc. These artifacts can be managed to the PDPT Framework by PDPT manager.

3.1 PDPT Framework Data Artifact Management

The PDPT Server SQL database manages the information (artifacts) in the context of their location in building environment. This context information is same as location information about user track. The PDPT core controls data, which are copied from the server to PDA client by context information (position info). Each database artifacts must be saved in database along the position information, to which it belongs.

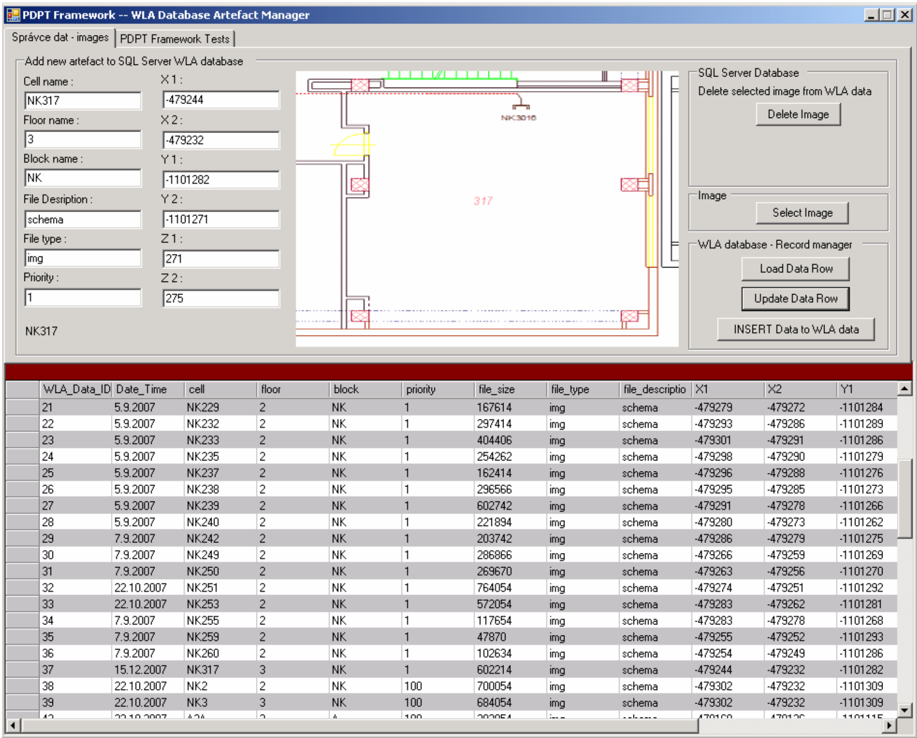

Fig. 10. PDPT Framework data artifact manager

During the creating process of PDPT Framework the new software application called "Data Artifacts Manager" was created. This application manages the artifacts in WLA database (localization oriented database). User can set the priority, location, and other metadata of the artifact. This manager substitutes the online conversion mechanism, which can transform the real online control system data to WLA database data artifacts during the test phase of the project. This manager can be also used in case of offline version of PDPT Framework usage [Fig 10].

The Manager allows to the administrator to create a new artifact from multimedia file (image, video, sound, etc.), and edit or delete the existing artifact. The left side of the screen contains the text field of artifact metadata as a position in 3D space. This position is determined by artifact size (in case of building plan) or binding of artifact to some part of a building in 3D space. The 3D axis is possible to take from building plan by some GIS software like Quantum GIS or by own implementation [4]. The central part represents a multimedia file and right side contains the buttons to create, edit, or delete the artifact. The lower part of the application screen shows actual artifacts in WLA database located on SQL Server.

4 Experiments – Data Transfer Test Using PDPT

We have executed a number of indoor experiments with the PDPT framework using the PDPT PDA application. The main result of utilization of PDPT framework is reduction of data transfer speed. The result of one of these tests is presented here. We focused on the real usage of developed PDPT Framework on wide scale of mobile lightweight devices and its main issue at increased data transfer. For test five mobile devices was selected with different operating system (Microsoft Windows Mobile 5.0, 6.0, 6.1) and a wide scale of memory, display resolution and user interface. For reliability of test we select a test track between two buildings of our university campus environment. User with each device go throw the defined environment where WiFi signal is present (number of AP vary from 1 to 4 visible at a time) ten times for better predicative value. For test we select two main collection of artifact according to their size (medium – 300-500 kB, large – 500-800 kB). During the movement of user the WiFi localization was enabled, so according the user position the artifacts was prebuffered to user PDA buffer (SQL CE database). At destination field we check the number of prebuffered artifacts and this number was compute as Successful rate [Table 2].

Table 2. Data transfer tests description

Test	Type of device	Data artifacts collection	Successful [%]
1	iPAQ h4150	Medium artifacts	84
2		Large artifacts	64
3	HTC Blueangel	Medium artifacts	91
4		Large artifacts	75
5	HTC Roadster	Medium artifacts	92
6		Large artifacts	79
7	HTC Universal	Medium artifacts	96
8		Large artifacts	84
8	HTC Athena	Medium artifacts	98
10		Large artifacts	87

The results surpass our expectations with high quality of successful rate. This rate varies from 84 to 98 % in Athena device case. With large artifacts collection these rates go quite down, but is still very useful for real using of PDPT framework. Is evident the prebuffering techniques can help to use of medium or large artifacts in information systems. If we can transform the real data from information system to artifacts with their positions information, we can improve the transfer rate of used wireless connection and have a better response to users.

5 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 WiFi 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 prebuffering and pushing information from server to user's PDA. Data prebuffering is the most important technique to reduce time from user request to system response.

We have executed a number of indoor experiments with the PDPT framework using the PDPT PDA Client application. WiFi APs was placed at different locations in building, where the access point cells partly overlap. We have used triangulation principle of AP intensity to obtain a better granularity. Currently, the usability of the PDPT Client is somewhat limited due to the fact that a device has to be continuously powered. If it is not, the WiFi interface and the application cannot execute the location determination algorithm and the PDPT server does not receive location updates from the PDA. This limitation was measured (by battery power level) with results, that is possible to use PDA devices with powered WiFi from 6 to 10 hours without battery replacement. The experiments also 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 WiFi infrastructure. For the PDPT framework application this was not found to be a big limitation for the PDPT framework application as it can be found at chapter Experiments. PDPT framework is currently used in another project of biotelemetrical system for home care named Guardian to make a patient's life safer. [7]. The second implementation of PDPT Framework (Technical University of Ostrava - integrated crisis management of facility management) is currently in development stage.

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