Complex Mobile User Adaptive System Framework for Mobile Wireless Devices

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Abstract. Paper describes a concept of User Adaptive System (UAS) as well as Predictive Data Push Technology (PDPT) Framework and Biotelemetrical Monitoring System (BMS) as two joined parts of complex UAS framework. Main focus is in contribution of UAS to user or patient and his life quality. A Position Oriented Database on a server and mobile devices is described as important part of whole UAS, because the position and context of user are one of the most important areas of UAS. Also the problem of low data throughput on mobile devices is described, which can be solved by PDPT framework. Localization and user tracking is described only as a necessary condition for prebuffering realization because the PDPT Core makes a decision when and which artifact (large data files) need to be prebuffered. Every artifact is stored along with its position information (e.g. in building or larger area environment). The accessing of prebuffered data artifacts on mobile device improve the download speed and response time needed to view large multimedia data. The conditions for real stocking in corporate areas are discussed at the end of paper along with problems that must be solved before stocking.

Keywords: User Adaptive System, Mobile Device, Localization, Biotelemetry, Position Oriented Database, Prebuffering.

1 Introduction

The idea of User Adaptive Systems (UAS) grown from interaction between user and system (e.g. throws his mobile device). Such interaction can behold in the reaction on user's non declared requests. These requests are based on current user environment and biological or emotional state (e.g where I am?, what I feel?, am I ok?, etc.). Such user questions can be answered by sensors on user body or inside the user devices. By the help of user mobile device, we can get a user location (e.g. user current position, user future-predicted position, his movement and tracking, etc.). Biomedical sensors on user body can detect several important biomedical data, which can be used for determination of user emotional state in the environment around.

By the combination of user's requests (known or predicted) in conjunction with other sources of user's knowledge and behaviors, the sophisticated information system can be developed based on presented UAS Framework.

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The impact of UAS can be seen in the increased user comfort when accessing these mobile UAS. In ideal case, everything what user can imagine to have in his mobile UAS is there.

A one specific kind of problems is based in increased data amount in new mobile systems. In current cases, the user need to specify a data to be downloaded to his mobile device and he need to wait for data downloading and displaying. Due to a several limitations in hardware of current mobile devices, the use of such large amount data has result in lower user comfort. The needs of any techniques to reduce such large data amount or to preload them before user's needs, is still growing up. We created a Predictive Data Push Technology (PDPT) Framework to solve these problems by data prebuffering. Our idea can be applied on a variety of current and future wireless network systems. More usability of PDPT grows from definition of area to be prebuffered as well as from evaluation of artifacts or other user's behavior sources. Additional will be presented in sections (3), (6).

The second area of problems which we would like to solve is based on a users biomedical data inputs and a wide area of their possible utility. Current body sensors allow a monitoring of a huge number of biomedical data information (e.g. use a special t-shirt equipped with an ECG, temperature, pressure or pulse sensors). Current hi-tech mobile devices are equipped with a large scale display, provide a large memory capabilities and a wide spectrum of network standards plus embedded GPS module (e.g. HTC Touch HD, HD2). These devices have built-in also a special accelerometer which can be used to determine a user's body situation (user is staying or lying). Last but not least equipment is a light sensor which can be used not only to brightness regulation. Use of these declared inputs will be discussed and presented in section (4).

2 Architectural Design for Ubiquitous Computing Systems

Ubiquitous Computing (UbiCom) is used to describe ICT (Information and Communication Technology) systems that enable information and tasks to be made available everywhere, and to support intuitive human usage, appearing invisible to the user [1].

Three basic architectural design models for UbiCom system can be divided to smart devices, smart environment and smart interaction. The concept of "smart" means that the object is active, digital, networked, can operate autonomously, is reconfigurable and has a local control of the resources which it needs such as energy, data storage, etc [1]. These three main types of system design may also contain subsystems, sub-parts or components at a lower level of granularity that may also be considered as a smart (e.g., a smart environment device may contain smart sensors and a smart controller, etc). An example of a three main types of UbiCom models is presented in (Fig. 1).

Many sub-types of smarts for each of the three main types of smarts can be recognized (Fig. 2). These main types of smart design also overlap between. Smart device can also support some type of smart interaction. Smart mobile device can be used for control of static embedded environment devices. Smart device can be used to support the virtual view points of smart personal spaces (physical environment) in a personal space which surrounding the user anywhere.

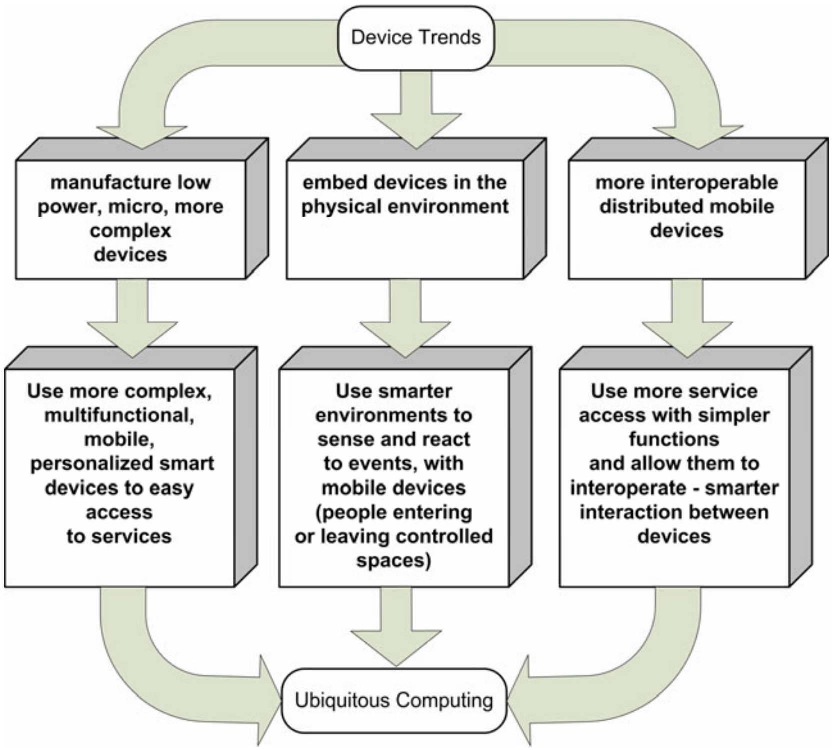

Fig. 1. Three models of ubiquitous computing: smart devices, smart environments and smart interaction [1]

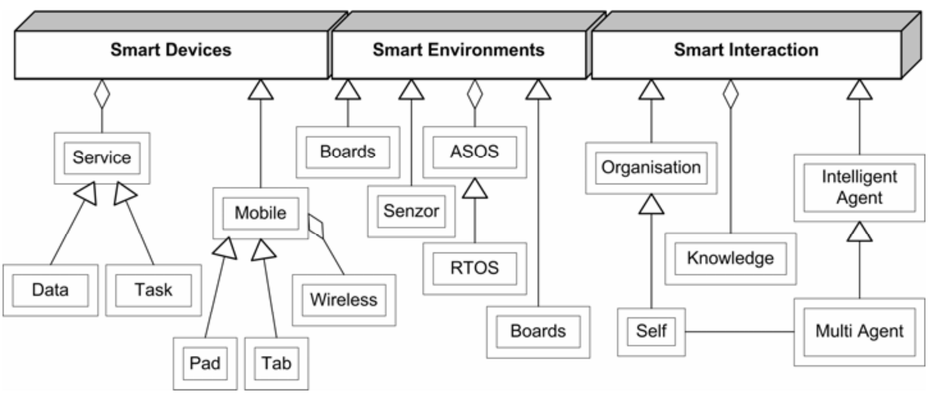

Fig. 2. Selected main subtypes of smart devices, environments and interactions including main aggregations between them. (MTOS is a Multi-Tasking Operating System, VM is a Virtual Machine, ASOS is an Application Specific or embedded system OS, RTOS is a Real-Time OS and MEMS is a Micro Electro Mechanical System) [1].

Satyanarayanan [3] has presented different architectures for developing UbiCom systems in way of which angle it is focused on a design:

1. Mobile distributed systems are evolved from distributed systems into ubiquitous computing
2. UbiCom systems are developed from smart spaces characterized by invisibility, localized scalability and uneven conditioning.

Poslad [1] has extended a Satyanarayanan model to Smart DEI model (Device Environment and Interactions). Poslads model also incorporates smart interaction. Smart DEI model also reverses to hybrid models (Fig. 2). It is widely assuming by users that the general purpose of end-user equipment will endure but also it will evolve into a more modular form.

2.1 Smart Devices

A smart device is a device that is digital, active, networked, user reconfigurable and that can operate to some extent autonomously. Smart devices can be characterized like personal computers or mobile phones with tend to be multi-purpose ICT devices. These devices operate as single portals used to access a multiple application services which are running locally on the device or remotely on servers. A range of forms are available for smart devices. Smart devices can be defined as personal devices, having a specified owner or user. In the smart device model, the place of application user interface is on side of the smart device. The main characteristics of smart devices consist of concept of: mobility, dynamic service discovery and intermittent resource access.

2.2 Smart Environments

A first definition of a smart environment brought by Coen [4] as a computation which is easily used to enhance ordinary activities. Cook and Das [5] refer to a smart environment as ‘one that is able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience in that environment’. A smart environment consists of a set of networked devices that have some connection to the physical world. The devices which are used for a smart environment usually execute a single predefined task (e.g., motion or body heat sensors coupled to a door release and lock control). Embedded environment components can be designed to automatically respond to interaction with user using iHCI (implicit Human Computer Interaction). A person can for example walk towards closed doors, which are automatically opens as a respond. By this reason the smart environments support a bounded, local context of user interaction. Smart environments will also follow a novel and revolutionary upgrades to be incorporated into the environment in the sense of a support less obtrusive interaction (pressure sensors can be for example incorporated into surfaces to detect a people sitting location or walking over).

2.3 Smart Interaction

While a smart devices and smart environments support the core properties of UbiCom, an additional type of design is needed to connect together their numerous particular activity interactions. Smart interaction is needed to support interaction model between UbiCom applications and their UbiCom infrastructure, physical world and human environments. In the smart interaction design model, system components dynamically interact to reach common goals. Components interact to reach goals jointly because they are deliberately not designed to execute and complete sets of tasks to reach goals all by themselves. There are several benefits to designs based upon sets of interacting components. Interaction between UbiCom system components does not exist only in one predefined level but it is spread in a range of levels from primitive to smart. Primitive interaction uses fixed interaction protocols between two statically linked dependent objects. While the smart interaction uses richer interaction protocols between multiple dynamic independent objects.

2.4 Adaptive Systems for Ubiquitous Computing

Ubiquitous computing provides a vision of computing systems which are located everywhere around us, embedded in the things of our everyday life. They provide an easy access to information and communications bases dedicated to our current location. People are able to interact with any ubiquitous computing environment which they attend. This is a reason why the ubiquitous computing environments must respond dynamically to specific user needs, resources dedicated to their owner's rights or to the current usage context. These require a high level of adaptivity which must be provided by ubiquitous computing systems and related connecting networks [2].

Described project deals with several of issues related to providing such adaptivity for ubiquitous computing environments which will be described more in the following sections.

3 Reaction on a Change of Location – Location-Aware Adaptation

We can imagine the usage of such described UAS in the information systems area of botanical or zoological gardens. In such areas there has been a big potential of usage of a continual localization by use of GPS or wireless networks (in case the GPS has not a sufficient signal – e.g. in urban centers or neighborhoods with high buildings, forest parks or in deep valleys). There is also a possibility to compute a current and predicted user track, so we can predict a position of user in near future (e.g. 25 meters north in one minute). Usability of these information sources is uncountable.

One of possible use of user predicted position is for a determination of a data, which will be needed by user of mobile UAS in near future. Such data (data artifacts) can be preloaded to user's device memory for future requests. The need of preloaded artifacts grown from a need of up to date data context of dynamic online system. Of course when static offline system is used, there is a possibility to load a needed data before usage (e.g store artifacts at SD Card with a size limit to several GB). When user request info about his location in context of zoo or garden (turn-on the device is only needed by user), the client application will respond with a map of near surroundings and a prebuffered data artifacts. User can select a documentary about animals or vegetation around him which can be viewed or played. 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 a user. The type of artifact is also evaluable as well as his size because the user may not want to look at too long or micro presentation. xxxxxxxx

As client devices of online UAS, the mobile wireless devices like PDA or Smart phones are commonly used equipped with internet connectivity. The connection speed of the two most common standards GPRS and WiFi varies from hundreds of kilobits to several megabits per second. In case of online UAS or some other types of facility management, zoological or botanical gardens, libraries or museums information systems, the WiFi infrastructure network is often used to interconnect mobile device clients with a server. Unfortunately, the low performance hardware components are used in PDAs or SmartPhones due to a very limited space. Due this a theoretical maximum connection speed is not reachable on such devices. The limited connection speed represents a problem for clients of online system using large artifacts (data files). In some specific cases it is not possible to preload these artifacts before the use of mobile device in a remote access state due any reason.

3.1 Low System Throughput on Current Mobile Devices

The real downlink speed for WiFi network (802.11b,g) is about 1280 kbit/s for modern PDA devices [7], [8], [9]. Primary dataflow can be increased by data prebuffering. Selecting of data objects to be buffered to mobile device cache is made on the base of position of user's device. For every position in area, where the prebuffering is being made, the location-aware objects for such user's position exists. PDPT Core pushes a data from SQL database (WLA database (Fig. 3)) to clients PDA on a base of PDPT Core decision algorithm.

The benefit of using a PDPT consists in reduction of time delay, which is needed to display requested artifacts from PDA client. This delay must not be longer than the time for which a user is able to wait for some response from application. Hence, the maximum response time of an application (PDPT Client) for user must be specified firstly. Nielsen in his book [10] specified this time delay to 10 seconds [11]. During this time the user was focused on the application and was willing to wait for an answer. The Nielsen book is a basic literature for this phenomenon. Galletta, Henry, McCoy and Polak (2002) findings suggest that, 'decreases in performance and behavioral intentions begin to flatten when the delays extend to 4 seconds or longer, and attitudes flatten when the delays extend to 8 seconds or longer'.

Based on this knowledge, we defined this delay for our testing purposes to 5 seconds. For this time is possible to transfer (from server to client) a data amount of 800 kB (for 1280 kbit/s downlink).

The next step was an average artifact size definition. The network architecture building plan is used as a sample database, which contained 100 files of average size of 470 kB. The client application can download during the 5 second period from 1 to 2 artifacts. The final result of several 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.

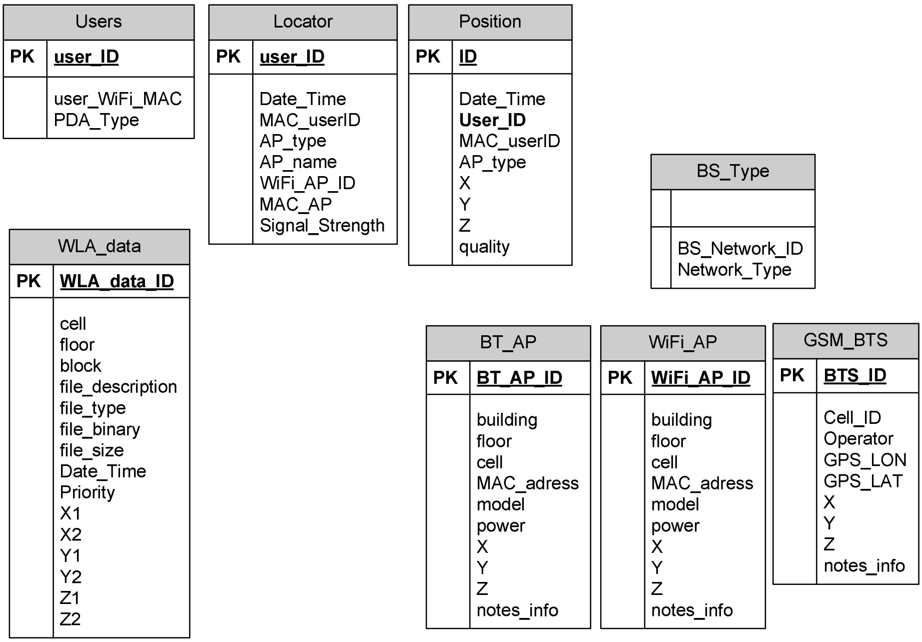

Fig. 3. Scheme of WLA architecture (Wireless Location Architecture) PDPT server database

3.2 Position Oriented Database

If the mobile device knows the position of the stationary device (transmitter), it also knows that its own position is within a range of this location provider [6], [12]. The typical range varies from 30 to 100 m in WiFi case, respectively 50 m in BT case or 30 km for GSM. Granularity of location can be improved by triangulation of two or more visible APs (Access Points) or using the more accurate position algorithms (Monte Carlo localization). In PDPT framework only the triangulation technique is used due to the sufficient granularity of user position information. Monte Carlo localization was tested in one segment of tested environment without marginal success

Table 1. PDPT Server – SQL Server 2005 database – *WLA_data* table

W.	cell	floor	block	file_...	file...	file_binary	file_size	Date_Time	Priority	X1	X2	Y1	Y2	Z1	Z2
36	NK260	2	NK ...	schema	img	<Binary ...	102634	7.9.2007...	1	-479254	-479249	-1101286	-1101282	267	271
37	NK317	3	NK ...	schema	img	<Binary ...	602214	15.12.20...	1	-479244	-479232	-1101282	-1101271	271	275
38	NK2	2	NK ...	schema	img	<Binary ...	700054	22.10.20...	100	-479302	-479232	-1101309	-1101248	267	271
39	NK3	3	NK ...	schema	img	<Binary ...	684054	22.10.20...	100	-479302	-479232	-1101309	-1101248	271	275
43	A2A	2	A ...	schema	img	<Binary ...	282054	22.10.20...	100	-479168	-479126	-1101115	-1101052	267	271
44	A213	2	A ...	schema	img	<Binary ...	601746	11.9.200...	1	-479134	-479126	-1101063	-1101056	267	271
45	A214	2	A ...	schema	img	<Binary ...	304790	11.9.200...	1	-479135	-479128	-1101065	-1101060	267	271
52	A221	2	A ...	schema	img	<Binary ...	271494	11.9.200...	1	-479149	-479142	-1101093	-1101087	267	271

PDPT Client Buffer		
PK	**ID**	**LONG**
	Date_Time cell file_type file_binary file_description	DATETIME VARCHAR(50) VARCHAR(50) BINARY(10) VARCHAR(50)

Fig. 4. PDPT Client – SQL Server 2005 Mobile Edition database – *Buffer* table

(Time needed to implement algorithm was inadequate to position quality results). Information about the user position are stored in *Position* table (Fig. 3). *Locator* table contain info about wireless AP with signal strength which are needed to determine user position. *WiFi_AP, BT_AP* and *GSM_AP* tables contain all necessary info about used wireless base stations. *WLA_data* table contain data artifact along with their position, priority and others metadata.

3.3 PDPT Client - Mobile Database Server

The large data artifacts from PDPT Server (WLA_data table (Fig. 3), (Table 1)) are needed to be presented for user on mobile device. In case of classical online system the data artifacts are downloaded on demand. In case of PDPT solution, the artifacts are preloaded to mobile device cache before user requests. As mobile cache the SQL Server 2005 Mobile Edition was selected. Our mobile cache contain only one data table Buffer (Fig. 4). Only the needed columns from PDPT server WLA_data table were taken for mobile version Buffer table. MS SQL Server 2005 Mobile Edition was selected for easiest managing of them in case that the Visual Studio and classic SQL Server are used. Small data amount for installation (2,5 MB) is also an advantage.

4 Reaction on a Change of Biomedical Data – Active Context-Aware Adaptation

A key problem of context-aware systems design is to balance the degree of user control and awareness of their environment. We can recognize two extreme borders as active and passive context-aware. In active context-aware system, the UAS is aware of the environment context on behalf of the user, automatically adjusting the system to the context without the user being aware of it [1]. This is a useful in our application where a strict time constraints exists, because the user-patient cannot due to immobility, or would not otherwise be able to adapt to the context quickly enough.

We are using principles of UAS in area of biomedical data processing, where we try to predict some kind of problems by patient data analysis. We developed a context-aware Biotelemetrical Monitoring System (BMS) [13] as a part of the UAS and PDPT Framework project facilitates the following:

- Real-time collection of the patient vital signs (e.g. ECG, EEG) by means of a Body Area Network (BAN) or direct wireless connection to PDA device monitoring station.
- Real-time transmission of the vital signs using the wireless connectivity to the healthcare professionals through a complete architecture including a server database, web services, doctors web access to patients collected and preprocessed data.
- Seamless handover over different wireless communication technologies such as BlueTooth, WiFi, GPRS or UMTS.
- Context-aware infrastructure to sense the context (e.g. location, availability, activity, role) of the patients and Emergency Response Services (ERSs) to provide assistance to the patient in case of an emergency. An ERS could be fixed (e.g. hospital) or mobile (e.g. caregiver). A mobile ERS is published in the BMS.

Classical access to patients request are made by reactive flowchart (Fig. 5.a), where a patient is equipped with a classical offline measuring devices with some type of alarms. Every violated alarm need to be a carried out by doctor decision. Such access is very time-consuming.

Second proposed access is based on a proactive principle (Fig. 5.b), where the patient is equipped with an online measuring devices with an online connection to some

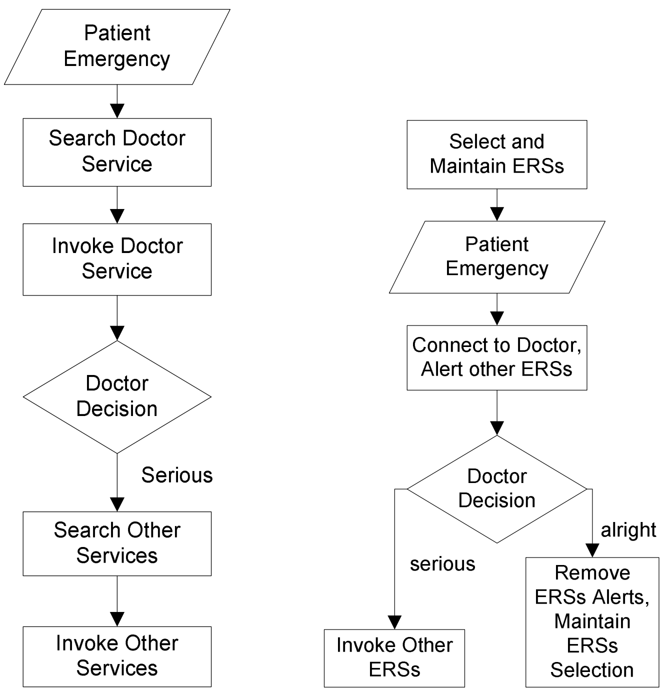

Fig. 5. Flowchart of Reactive (Left – Fig. 5.a) and Proactive (Right – Fig. 5.b) ERSs Selection and Invocation Approach.

kind of superior system (in our case the BMS is presented). In this case, a patient's measured data are processed on mobile monitoring station or at server. An alert will invoke when the anomaly data are founded in patient's records. Consequently the doctor is responsible to make a decision to invoke other ERSs or to remove Alarm (in case of false detection of anomaly). Such kind of behavior is based on UAS. In many of events a predicted and solved problems can save a life. The predicted patient's problems are in most cases minor in compare to a major problems detected in time where occurred.

4.1 Biomedical Data Acquisition, Processing and Proactive Reaction

Our developed BMS can currently handle two types of biomedical data:

- 12 channels wireless ECG – BlueECG (CorScience company)
- bipolar wireless ECG – corbel (CorScience company)

These data are measured, preprocessed on mobile monitoring station (PDA, embedded device, notebook), visualized on monitoring station's display (in available), sent by wireless connection to web service and stored on server for consequential access by doctors or medical personal. Used data acquisition devices provide a successful result in case of testing a developed solution. In near future we plan to use a t-shirt with equipped biosensors network (e.g. ECG, pulse, oxy, pressure).

The biomedical ECG data are continually processed (in Real Time) through a complete infrastructure of developed UAS. First false artifact recognition is made on mobile measurement stations near the patient to allow an immediate action from ERSs.

The more sophisticated data analysis is made at server level. This data processing is made on the base of neuron network and fuzzy logic behavior. Unfortunately, we reach only a small level of successful false detection (patient problem detection) up to date. In this area we are expected a future impact of our solution. The low detection rate is caused by several facts. Of course the better algorithms are needed at the first, but this problem cannot be solved satisfactory in near future. Another problem is caused by a slow connection by WiFi network, because some biomedical data contain a huge amount of data. This problem is possible to solve by our PDPT framework as a part of our UAS solution. By this solving, we improve the quality of detection by a 40 % (median value of 12 channels ECG). All the same, the real time transfer rate is now still fail to reach.

5 Reaction on a Change of Logged User – Personal-Aware Adaptation

Next possible way to react on user needs is in classical user input processing. Based on user login a personal-aware adaptation of UAS can be defined. Well known is a model of screen resolution adaptation based on a used mobile device. Classical way is in user setting module located in used application. This however requests a user action at each time a different user is logged in.

5.1 Adaptive User Interface for Mobile User Adaptive System

To prevent such waste user time, user interface adaptivity can be developed and used based only on user login information. UAS server can collect a user data such as a request of special user interface layout (font size, buttons size and locations, wide of scrollbars, etc.). After user login application is initiated in used best fitting scheme. Example of such user defined user interface is shown at (Fig. 6).

Depending on a user ability to view smaller fonts an indispensable number of other rows are viewable by user a higher resolution (Fig. 6).

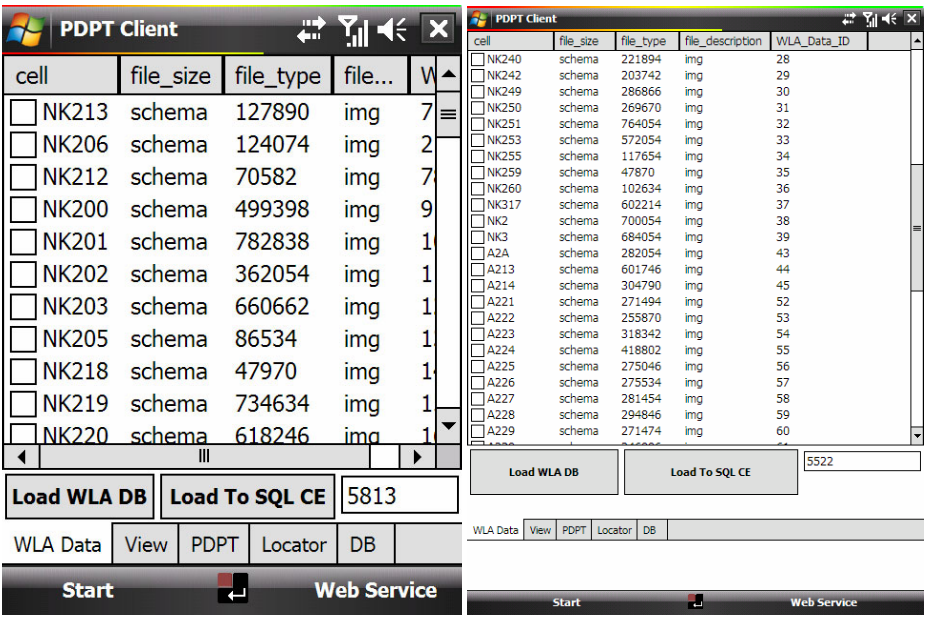

Fig. 6. User interface layout initiated based on UAS server data. QVGA layout on a VGA display (Left – Fig. 6.a) and VGA layout on same device (Right – Fig. 6.b)

5.2 New Components for Mobile User Adaptive Systems

However not every user is able to access small fonts so user interface with a large elements of user interface are welcome. Examples of such elements are described in (Fig. 7, 8, 9). A first example presents switchers (Fig. 7). They provide a sizable intuitive way to support an adaptation on user ability. Every described element is developed as components of UAS framework. Use in any other projects is therefore very easy and comfortable.

Another component of UAS framework is navigation arrows (Fig. 7.c.), which is a sizeable component with one enumeration type of direction which can be used to easily navigate in some outdoor use cases.

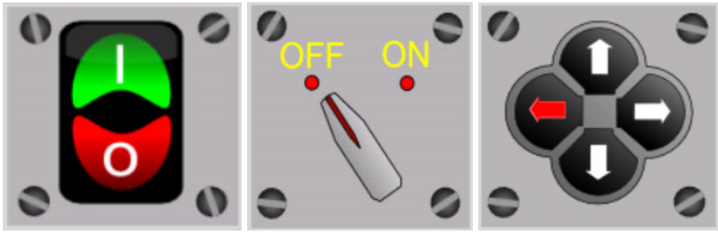

Fig. 7. User interface components: 0/1 switch (Left – Fig. 7.a), On/Off switch (Middle – Fig. 7.b) and navigation arrows where a left direction is selected (Right – Fig. 7.c)

Next component of UAS framework is circle visualizer (Fig. 8.a.), which is a sizeable component with two properties: color areas definition and min-max values. This component can be used to inform user about valued state of some controlled properties in the context of their boundary values. By use of this context a user can get more complex information instead of classical value information (e.g. in text/numerical form).

The last example of component is based on previous circle visualizer component, which is parent of a new component is sense of object programming model. The component can represent e.g. voltmeter (Fig. 8.b.) or milliammeter (Fig. 8.c.) as a two examples of measurement visualization component. From parent it inherits all properties and it adds a text properties for type of meter which it is represent in real case. Of course the shape is not a circle type, but it is rectangle.

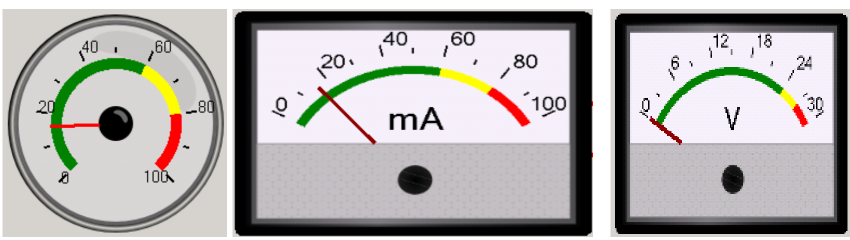

Fig. 8. User interface components of measurement visualization: value of 17 at circle visualizer (Left – Fig. 8.a), milliammeter (Middle – Fig. 8.b) and voltmeter (Right – Fig. 8.c).

6 The User Adaptive System Framework

A combination of a predicted user position with prebuffering of data, which are associated with physical location bears many advantages in increasing throughput of mobile devices. The key advantage of PDPT solution in compare to existing solutions [12], [13] is that the location processing, track prediction and cache content management are situated at server side. The solution allows for managing many important parameters (e.g. AP info changes, position determination mechanism tuning, artifacts selection evaluation tuning, etc.) online at a server. By adding a *Biomedical Data*

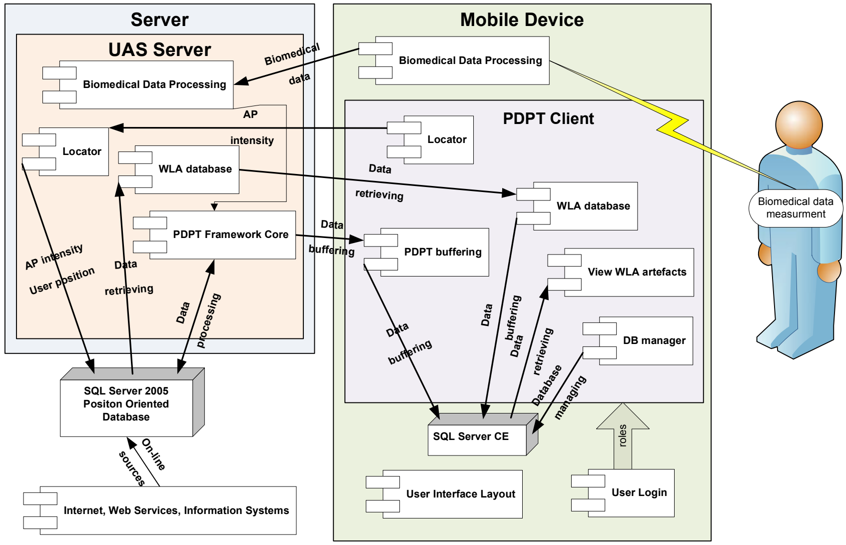

Fig. 9. User Adaptive System Framework architecture. Mobile device user is equipped with biotelemetry sensors to get info about user's body. User's mobile device has embedded WiFi connectivity, which is used in locator sensor component.

Processing solution, the Complex User Adaptive System (UAS) Framework is growing from (Fig. 10). While the whole PDPT Framework concept allow to manage a artifacts in context-awareness and time-awareness, the UAS Framework shift these possibilities to manage artifacts in biomedical context-awareness allowing a response for example to user´s non declared needs.

Biomedical Data Processing sensor at Mobile Device side of architecture (Fig. 10) collect information from user's body through a Bluetooth connection to any kind of wearable biotelemetrical devices. These data are transferred to UAS Server along with locator module data, which is processing these knowledge to act with adequate reaction in sense of user comfort improvement as a response time reducing for requested information by data prebuffering or any other reaction (e.g. screen resolution improvement, display brightness etc.).

Artifact data object can be defined as a multimedia file type in complex-awareness, which represent an object in Position Oriented Database – table *WLA_data* with time, position and biomedical-awareness. To manage locations of artifacts, firstly the building map is needed [15]. The position of corporate APs is also needed to determine a user position based on a distance from each visible APs [8], [12], [6]. All obtained positions info need to be stored in UAS server database through a PDPT Core web service. Artifacts with position coordinates are stored in *WLA_data* table (Table 1) by use of "WLA Database Artifact Manager". This software application was created to manage the artifacts in Position Oriented Database [8].

The PDPT prebuffering principle consists of several following steps:

1. Client must activate the PDPT buffering checkbox on PDPT tab at PDPT Client, which creates a list of artifacts (PDA buffer view sample which contain

only ID of artifacts), which are contained in his mobile SQL Server CE database.
2. PDPT Framework Core web service module creates own list of artifacts (imaginary view sample of PDA buffer) dedicated to actual user device position. It also compares it with real “PDA buffer view sample”. The area is defined as a 3D rectangle object where the user’s position is located in center.
3. The PDPT Core continues in next step with comparing of both images. If there are some missed artifacts in PDA buffer, they are prebuffered to PDA buffer. When all artifacts for current user position are prebuffered in PDA buffer, there is no difference between images.
4. After all artifacts are prebuffered to PDA buffer of mobile client, the PDPT Core is going to make steps 1 to 3 once more for a new predicted user position with new enlarged area (3D rectangle).

7 Discussion of Results

The PDPT Framework project is developed from 2005 until now in several consequential phases. Current state of the project is near the real company stocking. Final tests were executed in university campus of Technical university of Ostrava. For company stocking is possible to think about several areas. These possibilities will be discussed in [section 7.2].

7.1 Final Test Results of PDPT Framework Part

For testing purpose, five mobile devices were selected with different hardware and software capabilities. Six types of tests batches were executed in test environment. Two different test scenarios were executed as static and dynamic tests scenarios.

Static test was based on a predefined collection of data artifact which belongs to defined user position in test environment. Five test position were selected where approximately 12 data artifacts was needed to successful prebuffering. Three iterations were repeated in each position. If any of these expected artifacts stay un-buffered, the quality of prebuffering is going low. The tests were performed with result from 69,23 % to 100 %. The mean value of test results was 93,63 %. From all 15 tests, the 9 were executed with a 100 % of successful score.

Every dynamic test was between two points with 132 meter distance. Every even test was in reversed direction. Five iterations (five devices used) were made during one batch. Results provide a good level of usability when user is moving slowly (less than 0,5 m/s). This fact is caused by low number of visible WiFi APs in test environment, where 60 % of time only 1 AP was visible, 20 % for 2 visible and 5 % for 3 or more visible WiFi APs. 15 % of time represents a time without any WiFi connections. Reached values of prebuffering quality in such case are very good.

7.2 Possibilities of Using a PDPT Framework in Real Environment

Dynamic tests of PDPT Framework show the problem of a low number of visible WiFi APs for localization determination in the test environment of university campus. For the real case of usage and for the high level of prebuffering quality, the minimal number of simultaneously visible WiFi APs at each place of stocking area must be from 3 APs.

For successful stocking of PDPT, the area of prebuffering is needed to be defined and also the data artifacts must be defined. One way is in use of developed software “WLA Database Artifact Manager” for offline case, but the useful solution is in determination of large data objects in online case. Such determination is not easy. Possible solution can be seen in application of Position Oriented Database scheme to convert an existing server database of online system to Position Oriented Database structure. After such conversion, the data are possible to select based on position in stocking area. Consequently if data object – artifact can be selected, the PDPT server can prebuffer such data to mobile device.

As a summary, the PDPT is now usable at immobile patients at 100% successful rate of prebuffered artifacts. Such sort of patients is specific for only low speed of their transfer inside the environment. Due this fact the PDPT is functioning. If the environment for prebuffering will be equipped with a higher number of WiFi APs, the usability of PDPT in dynamic cases will be much more achievable.

8 Conclusions

A concept of UAS as well as PDPT Framework and BMS Framework was described with main focus on Position Oriented Database on server and mobile devices. Coexistence of proposed solutions is in unnumbered areas and the results of complex solution are better than expected. Also the final static and dynamic tests were performed and discussed. The developed UAS can be stocked on a wide range of wireless mobile devices for its main issue at increased downlink speed. The localization part of PDPT framework is currently used in another project of biotelemetrical system for home care agencies to make a patient’s life safer [13]. Several areas for PDPT stocking was founded in projects of Biotelemetry Homecare [14], [16]. In these selected areas the use of PDPT framework is not only partial, but complete include the use of wide spectrum of wireless communication networks and GPS for tracking people and urgent need of a high data throughput on mobile wireless connected monitoring devices. Several of UAS principles can be used there also. These possibilities will be investigated in future.

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