

Adaptivity Types in Mobile User Adaptive System Framework

Ondrej Krejcar

VSB Technical University of Ostrava, Center for Applied Cybernetics, Department of measurement and control, 17. Listopadu 15, 70833 Ostrava Poruba, Czech Republic
Ondrej.Krejcar@remoteworld.net

Abstract. User Adaptive Systems are nowadays widely used in modern information systems for their better reaction on user declared or nondeclared requests. Paper describes a concept of User Adaptive System (UAS) as a complex UAS framework. Main focus is in contribution of UAS to user or patient, his life quality and improvements of it. Several interesting examples of UAS are discussed and described as mobile application for sleep state detection as well as several developed user interface components for use at mobile devices.

Keywords: User Adaptive System; Mobile Device; Biotelemetry; UAS Components.

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.

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.

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.

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 sub-systems, 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).

Many sub-types of smarts for each of the three main types of smarts can be recognized. 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.

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. 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 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.

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.

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) [11] 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 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.

4.2 wakeNsmile Application – Proactive User Adaptive System

Proactive principle can be used not only in large distributed solution for medical centers, but it can be found usable in a many other solutions. One of them we found in an application to allow for people have a happy wake up. A mobile device application was developed to solve a problem of bad wake up at morning for all the people.

Sleep is a complex process regulated with our brain and as such is driven by 24 hour biological rhythm. Our biological clocks are controlled by chemical substances that are mostly known to us [12].

Approximately two hours after we fall asleep our eyes starts to move back and forth irregularly. Based on this fact scientists divided sleep stages into two main stages REM sleep with (Rapid Eye Movement) and NREM sleep stage (Non Rapid Eye Movement). NREM sleep is divided into another four sub-stages, when with increasing number the sleep is more and more deeper.

During healthy individual sleep, REM and NREM stages changes a few times. Most of the dreams are happening in REM stage. Body muscles are completely loosened and thanks' to this fact one is awoken refreshed.

During deep (NREM 3 and 4) sleep stages blood pressure is decreasing which lowers chance of cardiovascular danger. Also growth hormone is produced in its maximum in adolescent age [9]. Sleep stages are possible to divide into several: (a)

Wake (Awake), (b) REM – we dream in this stage, (c) NREM1 – falling asleep, (d) NREM2 – light sleep, (e) NREM3 – deep sleep, (f) NREM4 – deepest sleep.

wakeNsmile application (Fig. 1) was developed in C# programming language and uses .NET compact framework version 3.5, which is a special derivative of .NET framework for mobile devices [8]. Application was developed in Visual Studio 2008 Team Edition on Windows Mobile 6.5 emulator and tested on a Hewlett-Packard mobile device (originally HTC Roadster) with Windows Mobile 6.5 operating system. Minimal requirements for application running are Mobile device with Windows Mobile 6 and higher and .NET compact 3.5 or higher.

wakeNsmile application uses user control called Alarm, that has been created as a part of this project. Application is using Math.NET [10] neodym library for FIR (Finite Impulse Response) filter design and WaveIn and WaveOut libraries [11] for mobile device sound interface communication.



Fig. 1. wakeNsmile application example in Visual Studio 2008 Windows Mobile 6 emulator

wakeNsmile application is developed to react on users declared request in form of happy wake up at predefined time (Fig. 1). The time defined for alarm is however the latest possible time to wake up of user. We are trying to detect a body state in which the user is most able to wake up with a smile. Time period for detection analysis of state phases is declared to 30 minutes. A Fast Fourier Transformation (FFT) and some other sophisticated methods are used for it. Created application is an ideal example of user adaptive solution for mobile devices. Currently a single application is developed, but a distributed architecture version with a neural network analysis and people database is planned for future steps to be a completely embedded solution at Mobile UAS Framework. First test provide very promising results with more than 50 % of successful happy wake up of test persons at morning.

Developed application act as a proactive solution is sense of wake up of users in most suitable time.

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.

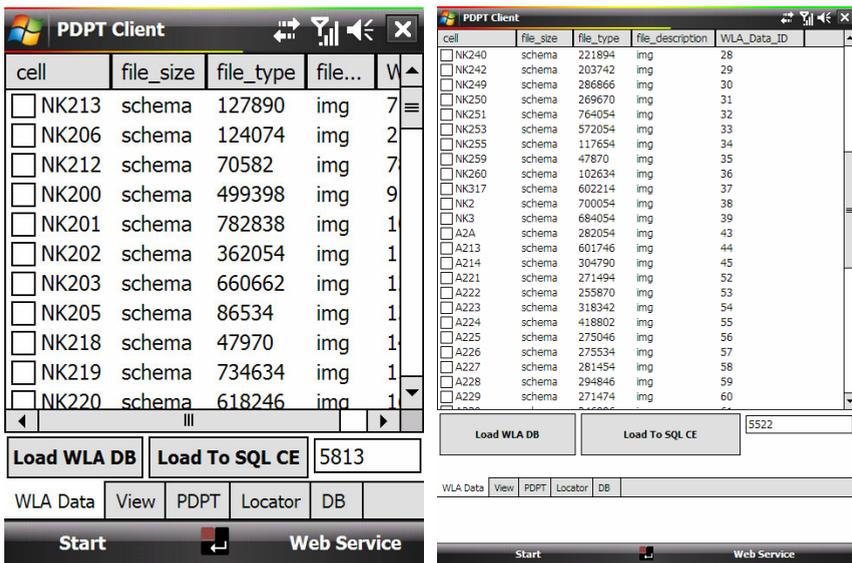


Fig. 2. User interface layout initiated based on UAS server data. QVGA layout on a VGA display (Left – Fig. 2.a) and VGA layout on same device (Right – Fig. 2.b).

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. 2).

Depending on a user ability to view smaller fonts an indispensable number of other rows are viewable by user a higher resolution (Fig. 2).

5.2 Adaptive 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. 3, 4). A first example presents switchers (Fig. 3.a., 3.b.). 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.

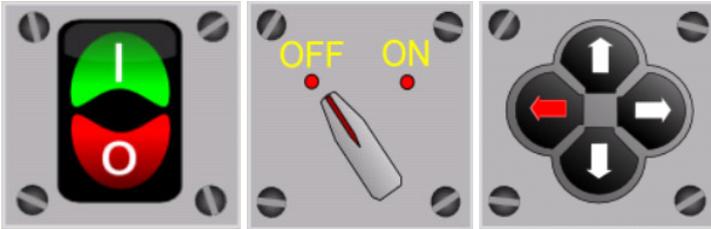


Fig. 3. User interface components: 0/1 switch (Left – Fig. 3.a), On/Off switch (Middle – Fig. 3.b) and navigation arrows where a left direction is selected (Right – Fig. 3.c)

Another component of UAS framework is navigation arrows (Fig. 3.c.), which is a sizable component with one enumeration type of direction which can be used to easily navigate in some outdoor use cases.

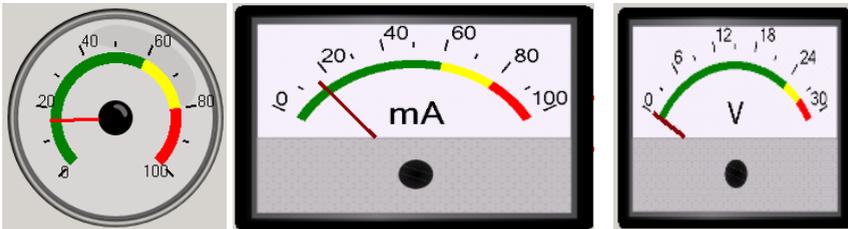


Fig. 4. User interface components of measurement visualization: value of 17 at circle visualizer (Left – Fig. 4.a), milliammeter (Middle – Fig. 4.b) and voltmeter (Right – Fig. 4.c)

Next component of UAS framework is circle visualizer (Fig. 4.a.), which is a sizable 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. 4.b.) or milliammeter (Fig. 4.c.) as 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.

5.3 Visual Indicator Components for Mobile User Adaptive Systems

The last examples of user interface components for UAS Framework are Battery and Signal Icons components [13]. Components are developed for .NET Compact Framework as well as previously described. Components visualize several cases of battery level state and wireless signal strength levels (Table 1). They all are stored in imageList. Components are designed to allow size adjusting as well as self adaptation on state of battery or signal level changes. Visual components (icons) have a more predicative value than use of classical text fields. The development resp. real states are show in (Fig. 5).

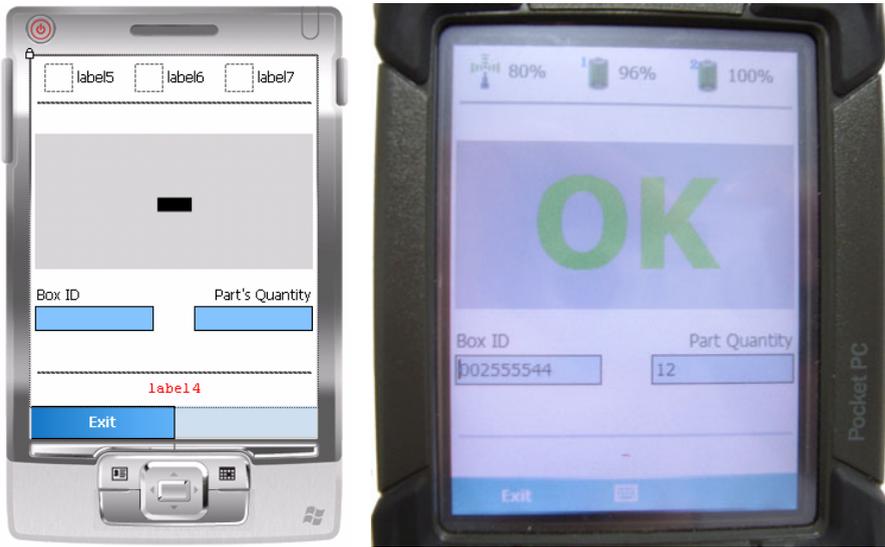


Fig. 5. Visual indicator components at development state in Visual Studio 2008 (Left – Fig. 5.a) and at real test (Right – Fig. 5.b)

Table 1. Battery and wireless signal icon components

| Icon description | level [%] | Icon | level [%] | Icon |
|--|-----------|------|-----------|------|
| Charging – main battery | 0% | | 20% | |
| Battery source – main battery | 30% | | 50% | |
| Charging – secondary battery | 10% | | 90% | |
| Battery source – secondary battery | 20% | | 40% | |
| Wireless signal strength level (0, 10, 50, 100%) | | | | |

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 [14] 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 Processing* solution, the Complex User Adaptive System (UAS) Framework is growing from (Fig. 6). 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. 6) 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

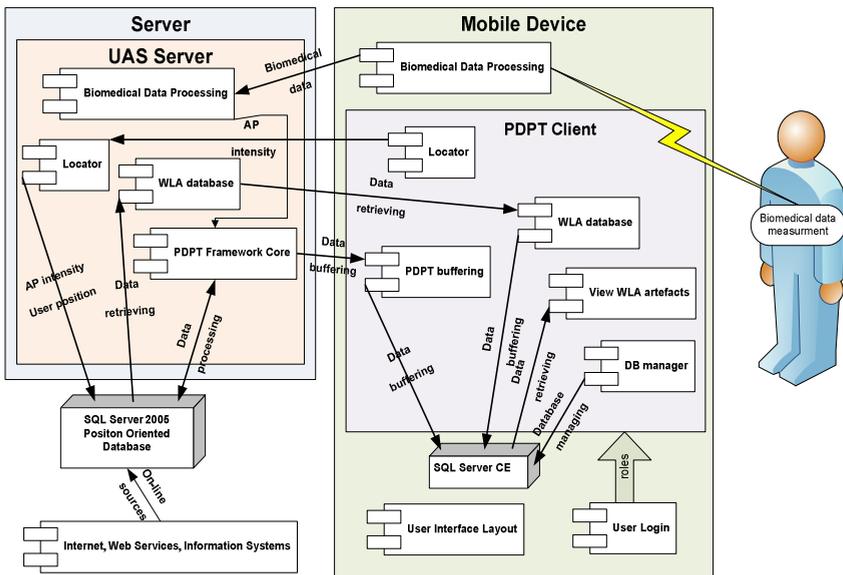


Fig. 6. User Adaptive System Framework architecture. Mobile device user is equipped with biotelemetry sensors to get info about user’s body.

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 [7]. 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 is well described in [16].

7 Conclusions

A concept of UAS Framework was described with main focus dealing with adaptive types of UAS on mobile devices. Coexistence of proposed solutions is in unnumbered areas and the results of complex solution are better than expected. The developed UAS Framework can be stocked on a wide range of wireless mobile devices. 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 [14]. Several areas for PDPT stocking was founded in projects of Biotelemetry Homecare. 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 like first one described developing wakeNsmile application or several adaptive user interface components. These possibilities will also be investigated in future.

Acknowledgement. This work was supported by the Ministry of Education of the Czech Republic under Project 1M0567.

References

1. Poslad, S.: *Ubiquitous Computing: Smart Devices, Environments and Interactions*. John Wiley & Sons, Ltd., London (2009) ISBN 978-0-470-03560-3
2. Lewis, D., O’Sullivan, D.: *Adaptive Systems for Ubiquitous Computing*. In: *Proceedings of the 1st International Symposium on Information and Communication Technologies*. ACM International Conference Proceeding Series, vol. 49, p. 156 (2003)
3. Satyanarayanan, M.: *Pervasive computing: vision and challenges*. *IEEE Personal Communications* 8, 10–17 (2001)
4. Coen, M.H.: *Design principles for intelligent environments*. In: *Proceedings of 15 th National / 10 th Conference on Artificial Intelligence / Innovative Applications of Artificial Intelligence*, pp. 547–554 (1998)
5. Cook, D.J., Das, S.K.: *How smart are our environments? An updated look at the state of the art*. *Pervasive and Mobile Computing* 3(2), 53–73 (2007)
6. Krejcar, O.: *Prebuffering as a way to exceed the data transfer speed limits in mobile control systems*. In: *5th International Conference on Informatics in Control, Automation and Robotics, ICINCO 2008, Funchal, Portugal, May 11-15*, pp. 111–114 (2008)

7. Krejcar, O., Cernohorsky, J.: New Possibilities of Intelligent Crisis Management by Large Multimedia Artifacts Prebuffering. In: I.T. Revolutions 2008, Venice, Italy, December 17-19. LNICST, vol. 11, pp. 44–59. Springer, Heidelberg (2008)
8. Krejcar, O.: Problem Solving of Low Data Throughput on Mobile Devices by Artefacts Prebuffering. EURASIP Journal on Wireless Communications and Networking, Article ID 802523, 8 (2009)
9. Rechtschaffen, A.: Current perspectives on the function of sleep. *Perspectives in Biological Medicine* 41, 359–390 (1998)
10. Math.NET documentation, <http://mathnet.opensourcedotnet.info/doc/> (OpenSource NET Projects 2002 - 20010)
11. Recording and Playing Sound with the Waveform Audio Interface (January 2004), <http://msdn.microsoft.com/en-us/library/aa446573.aspx> (Seth Demsey – Microsoft)
12. Krejcar, O., Jirka, J., Janckulik, D.: wakeNsmile - Mobile Phone Application for Sound Input Analysis and Sleep State Detection. In: Proceedings of 2nd International Conference on Mechanical and Electronics Engineering, ICMEE 2010, Kyoto, Japan, August 01-03, vol. 2. IEEE Conference Publishing Services, NJ (2010)
13. Krejcar, O., Macecek, M.: Development of Bar Code Scanner Application for Windows Mobile Devices Using a Symbol Mobility Developer Kit for .NET Compact Framework. In: Proceedings of 2nd International Conference on Mechanical and Electronics Engineering, ICMEE 2010, Kyoto, Japan, August 01-03, vol. 2. IEEE Conference Publishing Services, NJ (2010)
14. Krejcar, O., Janckulik, D., Motalova, L., Kufel, J.: Mobile Monitoring Stations and Web Visualization of Biotelemetric System - Guardian II. In: Mehmood, R., et al. (eds.) EuropeComm 2009. LNICST, vol. 16, pp. 284–291. Springer, Heidelberg (2009)
15. Krejcar, O.: Full Scale Software Support on Mobile Lightweight Devices by Utilization of all Types of Wireless Technologies. In: Granelli, F., Skianis, C., Chatzimisios, P., Xiao, Y., Redana, S. (eds.) Mobilight 2009, May 18-20. LNICST, vol. 13, pp. 173–184. Springer, Heidelberg (2009)
16. Krejcar, O.: Complex Mobile User Adaptive System Framework for Mobile Wireless Devices. In: Mobilight Workshops 2010, Barcelona, Spain, June 30 – July 02. Social- Informatics and Telecommunications Engineering, LNICST, Springer, Heidelberg (2010)