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Nomad Devices Adaptation for Offering Computer Accessible Services

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1. Introduction

During the last years a transition from desktop computers and fixed phones to nomad devices such as mobile phones, palmtops and mobile Personal Computers has been experienced. Their market penetration is continuously increasing, mainly because they offer to their users the possibility to stay connected with their near ones and with the world whenever and wherever possible.

The technological development of the aforementioned nomad devices provides not only the chance but the need to explore these systems in order to provide computer-based interactive applications and services accessible to the broadest possible population. At the same time, this development must also cope with diversity of the end users, the access media and devices, as well as in the contexts of use.

The adaptation of nomad devices, applications and services, for the benefit of people with disability and of the elderly is especially challenging. This is because it requires a revision of the traditionally prevailing Human Computer Interaction (HCI) assumptions, such as that of designing for a non-disabled user in a desktop environment.

ASK-IT[1] (Ambient Intelligence Systems of Agents for Knowledge Based and Integrated Services for Mobility Impaired People) is a European Integrated Project (IST-2003-511298) within the IST 6th Framework Program in the e-Inclusion area. The driving vision behind the project is to develop services based on Ambient Intelligence (AmI) and Information and Communication Technologies (ICT) that allow mobility impaired people to move independently, live a quality life, and as a result, establish and secure economic and social inclusion. These services include the provision of relevant and real-time information, primarily for travelling, but also for use at home and at work. Nomad devices allow content access at any time, at any place, and across multiple networks. These devices combined with the ASK-IT platform aim at covering a wide range of the mobility impaired users personal needs (Gardner, 2006). ASK-IT provides applications and services in five main areas:
(i) transportation, tourism and leisure; (ii) personal support; (iii) work; (iv) business and education support; and (v) social relations and community building (ASK-IT, 2004).

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1 http:// www.ask-it.org

This chapter describes the technological solutions adopted in the framework of the ASK-IT project in order to offer services and interfaces adapted to the special needs and demands of mobility impaired people.

2. Materials and Methods

2.1 Hardware and Software User Interface Solutions Relevant to the Platform

In this section it is considered the adopted technical approach in relation to four different aspects of the User Interface (UI) configuration: device form factors, operating system, runtime software and networking technology.

Three device form factors have been chosen for the application development and user testing, supporting the targeted scenarios (Alcaine & Salmre, 2006):

- **Smart Phone** is today's most common nomad device. Smart Phones are full-featured mobile phones with personal computer like functionality, rich displays and miniature keypads for text entry. Voice input and output capabilities are also inherent to this form factor.
- **Personal Digital Assistant (PDA)** represents a richer user input/output modality than Smart Phones, with larger touch screens, better feature sets and more powerful processors.
- **Mobile Personal Computer (PC)** has the largest display area among nomad devices and the most flexible user input mechanism, at the cost of a larger size than Smart Phone and PDA form factors. The Ultra Mobile PC (UMPC), attractive because of its portability, deserves to be highlighted here.

The choice of the selected **Operating Systems (OS)** was based on the features needed or preferred by end-users, as well as on their potential commercial exploitation. Finally, three operating **systems allowing Java development**, based on the Mobile Information Device Profile (MIDP) combined with the Connected Limited Device Configuration (CLDC), have been selected (Alcaine & Salmre, 2006):

- **Symbian OS** is a widely used operating system, available on many Smart Phones.
- **Windows Mobile OS** is a commonly used operating system for mobile devices such as PDAs.
- **Windows Tablet PC** is a version of Windows OS with specific Tablet functionality enhancements facilitating interaction with or without keyboard.

A "run-time" is a programming system that lies on top of an O.S. and aids in the development of rich software. The final implementation was based on Java Run-Time Environment (JRE).

Solutions adopted with respect to hardware and Operating Systems support some sub-set of the following networking technologies (Alcaine & Salmre, 2006):

- **GPRS/UMTS** represents data communications over mobile Wide Area Networks (WAN).
- **Wi-Fi** represents Wireless communications over Local Area Networks (LAN).
- **Bluetooth/Zigbee** provides optimized communications for Body Area Networks (BAN) and Personal Area Networks (PAN).

The specific devices used by mobility impaired users during the Project trials were, among others:

- **Smart Phones:** Nokia N95[2], Nokia E90[3]
- **PDAs:** HTC Touch Dual[4], HTC Touch Find
- **Mobile PCs:** Fujitsu FMV-U8240[5], ASUS R2H

The UI configuration of the final system takes into consideration the functional limitations of the user, the type of service that needs to be supported in each case, the context of use, and finally, the benefits offered by each one of the nomad devices (Ringbauer & Hipp, 2008).

2.2 Application Design Guidelines for Nomad Devices

This section reviews several design guidelines that have been considered for the development of applications for nomad devices (Häkkilä & Mäntyajärvi, 2006):

- **GL1. Consider the uncertainty in decision-making situations:** the designer should weight whether the user must be made aware of the uncertainties. This guideline leads the application designer to consider if the device asks the user a confirmation before executing actions.
- **GL2. Prevent from interruptions**: the designer should consider the priority order of actions and whether the user's interruptability in certain situations can be taken into account.
- **GL3. Avoid information overflow**: the device should not seek to present too much information to the user at once, and the presented information should be arranged in a meaningful and understandable manner.
- **GL4. Enable personalization:** the designer should consider using customization to meet the user's individual needs. This can be done, for instance, by implementing filtering according to the user's personal preferences.
- **GL5. Secure the user's privacy:** applications employing information sharing require special care in privacy issues. Possibility of anonymity should be provided.
- **GL6. Remember mobility**: simple and fast interaction should be favoured, as the user may interact with the device while moving or doing something else. The designer must consider how mobility affects the availability and use of the context information – for instance to the available data connections or location detection accuracy.
- **GL7. Guarantee the user control**: the user should always be able to get control over the device. In addition, the designer should consider if there is a need to drop the automation level or ask for confirmation from the user instead of executing fully automated actions.
- **GL8. Customise access to context:** sometimes it may be appropriate to provide the user with the possibility to edit context attributes and their measures. Letting the user rename locations or other context attributes can increase the intelligibility of the application.
- **GL9. Provide visibility of system status:** visibility of system status should be provided for the user to understand and keep up what the device is doing. In addition to general

[2] http://www.nokia.com/

[3] http://www.nokiausa.com/

[4] http://www.htc.com/

[5] http://www.fujitsu.com/

issues, such as showing feedback of executed actions, having logs or history information can be appropriate.

- **GL10. Enhance usefulness**: as an overall point when designing a context awareness application, attention should be paid to the utility value of the provided information and device adaptation.

2.3 User Interface Design Guidelines Applied to Nomad Devices

This section lists some of the main design guidelines that have been considered when designing UIs for nomad devices.

Half of Shneideman's eight interface design guidelines (Schneiderman, 1997) apply to nomad devices without explicit changes (Gong & Tarasewich, 2004):

- **IDGL1. Enable frequent users to use shortcuts:** the user's desire to reduce the number of interactions increases with the frequency of use.
- **IDGL2. Offer Informative feedback:** for every operator action, there should be some system feedback, substantial and understandable by the user.
- **IDGL3. Design Dialogs to yield closure:** users should be given the satisfaction of accomplishment and completion.
- **IDGL4. Support Internal Locus of Control:** systems should be designed such that users initiate actions rather than respond to them.

The remaining four guidelines require modifications and/or an increased emphasis on its use with nomad devices:

- **IDGL5. Consistency:** the designer should guarantee that applications maintain their coherence across multiple platforms and devices.
- **IDGL6. Reversal of actions:** this issue may be more challenging for mobile devices, because of the lack of available resources and computing power (Satyanarayanan, 1996).
- **IDGL7. Error prevention and simple error handling:** error management is always an important issue, but it becomes more critical in the mobile environment due to a more rapid pace of events (Gong & Tarasewich, 2004).
- **IDGL8. Reduce short term memory load:** interfaces should be designed such that very little memorization from the user side is required during the tasks performance. Using alternative interaction modes such as sound can be beneficial (Chan et al., 2002).

Additional guidelines for mobile device design are (Gong & Tarasewich, 2004):

- **IDGL9. Design for multiply and dynamic contexts:** the usability or appropriateness of an application (e.g. brightness, noise levels, weather) can change depending on location, time of day and season (Kim et al., 2002).
- **IDGL10. Design for small devices:** as technology continues to advance, mobile platforms will continue to shrink in size and include items such as bracelets, rings, earrings, buttons, and key chains.
- **IDGL11. Design for limited and split attention:** interfaces for mobile devices need to be designed to require as little attention as possible (Poupyrev et al., 2002).
- **IDGL12. Design for speed and recovery**: for mobile devices and applications, time constraints need to be taken into account in initial application availability and recovery speed.
- **IDGL13. Design for top-down interaction:** the use of multilevel or hierarchical mechanisms might be a better way of presenting information to reduce distraction, interactions, and potential information overload (Brewster, 2002).

- **IDGL14. Allow for personalization:** since nomad devices are more personal than traditional ones, it is more likely that a user of mobile applications will personalize the device and its applications to his preferences.
- **IDGL15. Design for enjoyment:** since aesthetics is also part of designing an overall enjoyable user experience with mobile devices.

2.4. User Interface Approach

Within the ASK-IT project, prior to the final integration of the UI in the ASK-IT devices, the following services' prototypes have been built: route guidance, e-commerce & e-payment, domotics, Advanced Driver Assistance Systems & In-Vehicle Information and Communication Systems (ADAS/IVICS), medical, e-working & e-learning and assistive devices (Bekiaris & Gemou, 2005).
Figure 1 shows an ASK-IT mock-up using a PDA as a nomad device. The ASK-IT services are grouped on application domain related categories: Route planning, Points of interest, Domotics, Assistance and My car.
Most of the systems reported in the literature dealing with content adaptation for small devices consist of tailoring several presentations of the same content to different kind of devices. The difficulty of such approach is that it requires a lot of human efforts in authoring and storing the different content variants.

Figure 1. Mock-up illustrating the Services menu (Ringbauer, 2006)

The concept of automatic software adaptation reflects the capability of the software to adapt, during runtime, to the individual end-user, as well as to the particular context of use, by delivering the most appropriate interface solution. For the UI adaptation in ASK-IT, the Decision Making Specification Language (DMSL), which includes a method for automatic adaptation-design verification, was found to be a useful solution (Savidis & Ioannis, 2006). This solution was adopted with Mobile PCs, with satisfactory performance results. However, due to capacity device restrictions, the traditional model for content adaptation had to be used in Smart Phones and PDAs.

3. Results

This section illustrates and describes some of the implemented UIs.
Figure 2 illustrates the "Access menu" UI interface implemented for the PDA form factor. It shows the use of shortcuts (IDGL1) and the design for limited and split attention, by using icons (IDGL11).

Figure 2. Screenshot of the Access menu for a PDA

Figure 3 illustrates the final "Services menu" UI for a Smart Phone. Compared with the PDA mock-up from Figure 1, only textual and basic information is presented, in accordance with guideline GL3.

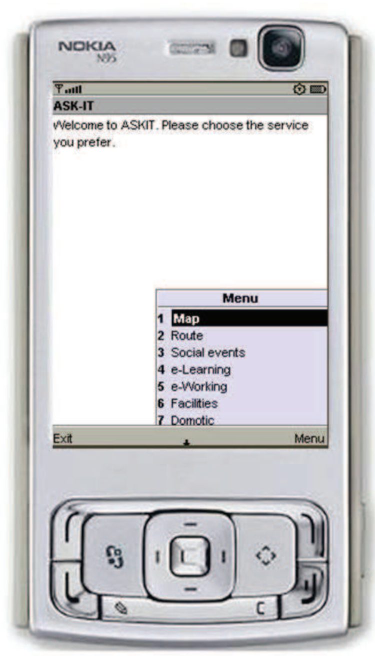

Figure 3. Screenshot of the Services menu UI for a Smart Phone

Figure 4 presents the ASK-IT UI for the domotics scenario in a Smart Phone. The image on the left shows how the user selects the room he is interested in controlling. The image on the right informs the user about the current status of the system following guideline IDGL2, as well as guideline GL4, since it is implemented in black and white, assuring adaptation to visually impaired users needs.

Figure 4. Domotics UI for a Smart Phone (left). UI adapted to a visually impaired user, indicating the status of several devices in the bedroom (right)

Figure 5. ASK-IT Emergency support scenario UI for a PDA

Figure 5 shows the UI developed for the emergency support scenario. It is compliant with guideline GL9, since the device informs the user about the detection of a medical emergency, and with GL7, as the system asks for user confirmation before sending an ambulance, instead of executing fully automated actions.
Figure 6 shows the final implementation of the UI providing Points of Interest (POI) search functionality, integrated with the “Guide Me” navigation service. After the user performs a POI search operation and receives results, the available POIs are displayed on a map, and if clicked, further information is given.
This specific UI illustrates some of the principles described before. It provides auditory information by clicking on the loudspeaker icon in the upper right corner, making the information available for hearing impaired users (GL4). The positive effect of sound in user interface design of mobile devices has been shown in several studies (Brewster & Cryer, 1999; Brewster & Walker, 2000). Moreover, it provides the user with the possibility to reverse his actions (IDGL6) by clicking on the “Back” button.

Figure 6. PDA screenshot illustrating POI search functionality (left). Information provided for a specific POI (right)

Figure 7 depicts the UI designed specifically to offer information about social events on a Mobile PC. Compared with the previously described ones, this device is most useful when the user is at home or at work. The screen is divided into six different areas: welcome, help and log-out buttons, at the top; navigation, to the left; shortcut buttons; system status; information, which provides the data and position of the user, at the bottom; and a content area, in the centre. It takes into account guideline GL10, since it is aiming to provide useful information to the user about social events that may improve his social relations and leisure time.

Figure 7. UI developed for the Social events service for a Mobile PC

4. Validation

This section provides the preliminary evaluation results from some stand-alone tests of the ASK-IT applications and UIs carried out during June 2008 in several locations of Spain and Greece.

Nine users, with ages ranging from 18 to 68 and with diverse disabilities, participated in the tests and subsequent evaluation.

They received a two hours training session explaining the testing objectives, the specific services and applications that have been developed and describing the tests and the evaluation process.

Feedback from the users was gathered through pre-test questionnaires, mainly designed to obtain demographic data, and post-test questionnaires to assess both the content and the tools utilized.

Figure 8, Figure 9 and Figure 10 illustrate some of the results obtained.

Generally users were satisfied with the graphical interface (GL4) of the system (see Figure 8 left), except the ones that dealt more with maps (POI Search). This is due to the fact that ASK-IT uses the original maps of each service provider and cannot modify them. The font size was thought to be small and zoom was necessary for most of the cases (Figure 8 right).

Figure 9 (left) illustrates that colour contrast was not satisfying for many participants, especially for outdoor users during the planning a trip task. Figure 9 (right) shows that 3 out of 9 participants thought it was difficult to cancel a wrong selection while planning a trip. As the complexity of the service menu increased, the more difficult it seemed to re-adjust wrong selections or to get help from the menu.

Figure 10 (left) shows that for activities such as domotic interaction, planning a trip and searching for social events, the possibility of using touch screens should be considered.

Figure 10 (right) demonstrates that 67% (N=6) of the participants thought the information provided was helpful (GL10).

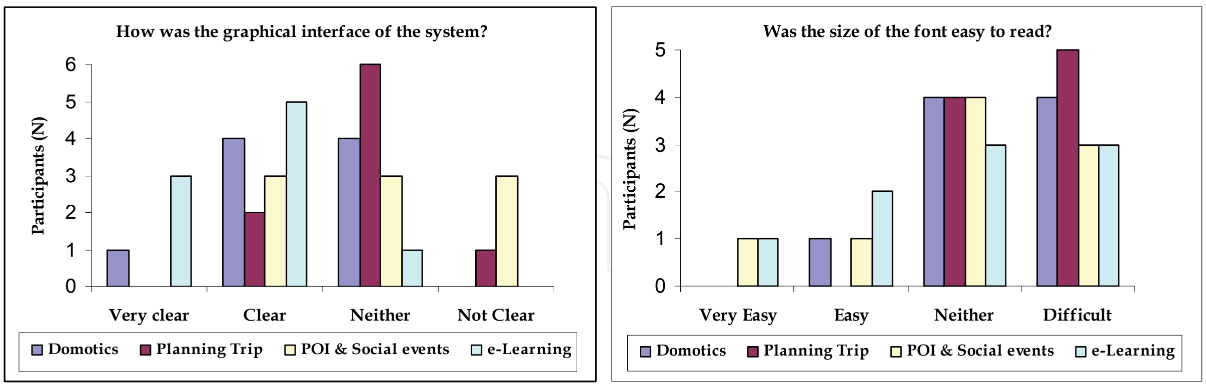

Figure 8. Evaluation results about the clarity of the UI (left). Ease of reading textual information (right)

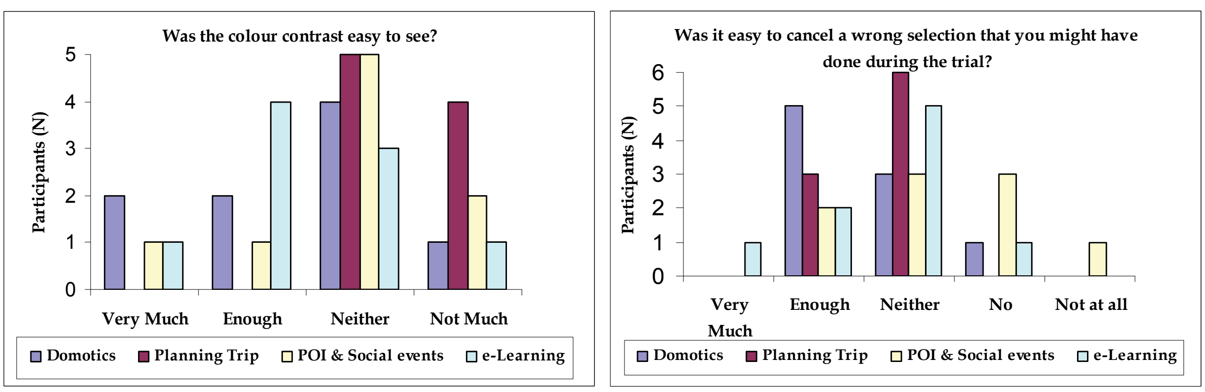

Figure 9. Evaluation results about the colour contrast (left). Ease of cancelling a wrong selection (right)

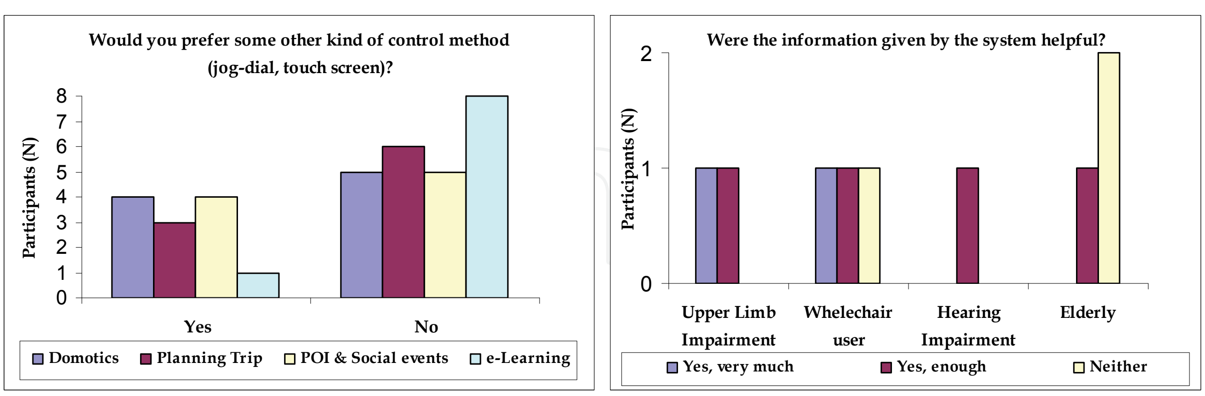

Figure 10. User satisfaction with the input/output modality (left). Usefulness of the information provided by the system (right)

Initial tests have provided useful information about the developed applications and UIs, including their adaptation to nomad devices and to the needs of disabled users and the elderly. Further integrated trials with an extended number of users are envisaged to demonstrate the feasibility and viability of the implemented solution.

6. Conclusion

This paper builds on the importance of supporting the adaptation of the User Interface to different devices and diverse user needs. This is particularly relevant in the case of nomad devices - Smart Phones, PDAs and Mobile PCs - as they allow the user to access information at any time and at any place. Several hardware and software UI design options have been described. Some of the UIs currently implemented have been presented for several scenarios, underlying their compliance with the design guidelines for UIs and applications for nomad devices, and their diverse adaptations to each user.

So far, the automatic adaptation of the UIs using the DMSL has only been possible with Mobile PCs. Future steps should include dynamic UIs adaptation using other types of nomad devices.

Current developments show UI adaptation based on the user profile and more specifically, on the user disability. Future implementations should take into account a possible adaptation based on the context and user preferences.

Results already gathered from stand-alone tests, together with results to be obtained from integrated tests will provide useful information for future improvements of the developed applications and user interfaces. They will also contribute to enhance the access to information and the quality of life of disabled users and the elderly.

7. Acknowledgements

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8. References

Alcaine, P. & Salmre, I. (2006). *Internal Report* ASKIT-SIE-WP33-R1-V11, Target Devices Specifications. ASK-IT Project. (IST-2003-511298).

Bekiaris, E. & Gemou, M. (2005). *Internal Deliverable* ASK-IT ID3.2.1-final, Definition of Configuration Parameters. ASK-IT Project. (IST-2003-511298).

Brewster, S. (2002). Overcoming the Lack of Screen Spaces on Mobile Computers, In: *Personal and Ubiquitous Computing*, Springer (Ed.), pp. 188-205.

Chan, S.; Fang, X.; Brzezinski, J.; Zhou, Y.; Xu, S. & Lam, J. (2002). Usability For Mobile Commerce Across Multiple Form Factors, *Journal of Electronic Commerce Research*, Vol. 3, No. 3 (187-199).

Gardner, M. (2006). Nomadic devices. Toward simpler, *Standardized Integration into Vehicles Via a Nomadic Gateway*.

Gong, J. & Tarasewich, P. (2004), Guidelines for handheld mobile device interface design, *Proceedings of the 2004 DSI Annual Meeting*, Boston, MA, USA, November 2004.

Kim, H.; Kim, J.; Lee, Y.; Chae, M. & Choi, Y. (2002). An Empirical Study of the Use Contexts and Usability Problems in Mobile Internet, *Proceedings of the 35th Hawaii International Conference on System Sciences*, ISBN: 0-7695-1435-9, Big Island, Hawaii, January 2002, IEEE Computer Society, Washington, DC, USA.

Hákkilä, J. & Mäntyjärvi, J. (2006). Developing Design Guidelines for Context-Aware Mobile Applications, *Proceedings of the 3rd International Conference on Mobile Technology Applications & Systems*, Art. 24, ISBN: 1-59593-519-3, Bangkok, Thailand, October 2006, ACM, NY, USA.

Lemluma, T. & Layaïda, N. Context-aware adaptation for mobile devices, *Proceedings of the IEEE International conference on Mobile Data Management*, pp.106-111, Berkeley, CA, USA, January 2004, IEEE.

Poupyrev, I; Maruyama, S; Rekimoto, J. (2002). Ambient Touch: Designing Tactile Interfaces for Handheld Devices, *Proceedings of the 15th Annual ACM Symposium on User Interface Software and Technology*, pp. 51-60, Paris, France, 2002.

Ringbauer, B. (2005). Smart Home Control via PDA - an Example of Multi-Device User Interface Design. In: A. Sloane (Ed.), *Proceedings of the Home oriented Informatics and Telematics Conference (HOIT 2005),* ISBN-10: 0387251782, York, UK, April 2005, Springer, London.

Ringbauer, B. (2006). Internal Deliverable ASKIT ID2.10.2_v01, Simulation and mock/up of all devices for MI. ASK-IT Project. (IST-2003-511298).

Ringbauer, B. & Hipp, C. (2008) ASK-IT Deliverable D.2.10.1. Full Set of Interfaces Concepts and Prototypes. ASK-IT Project. (IST-2003-511298).

Satyanarayanan, M. (1996). Fundamental Challenges in Mobile Computing, *Proceedings of the Fifteenth Annual ACM Symposium on Principles of Distributed Computing*, pp. 1-7, ISBN: 0-89791-800-2, Philadelphia, Pennsylvania, USA, May 1996, ACM.

Savidis, A & Lilis Ioannis, L. (2006). Internal deliverable ASK-IT-ID3.2.2, UI Configuration according to user abilities.

Schneiderman, B. (1997). *Designing the User Interface: Strategies for Effective Human Computer Interaction*, Addison-Wesley, ISBN: 0201694972, Boston, MA, USA.

Stephanidis, C. & Savidis, A. (2003). Unified User Interface Development. In: J. Jacko & A. Sears (Eds.), *The Human-Computer Interaction Handbook - Fundamentals, Evolving Technologies and Emerging Applications* (pp. 1069-1089). Mahwah, New Jersey, Lawrence Erlbaum Associates.

Annex 1- Description of Work. (2004). ASK-IT Project (IST-2003-511298).