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Considering the User in the Wireless World

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Abstract

The Wireless World Research Forum (WWRF) is a global academic and industry forum, which is contributing to the visions of future wireless communications and identifying research topics on which to build the vision. The near future promises significant advances in communication capabilities, but one of the keys to success will be understanding what capabilities people will find valuable, and how to make those capabilities simply usable. In considering the role of the user in the wireless world of the future, Working Group 1 of the WWRF has gathered input and developed positions in four important areas: methods, processes and best practices for user-centered research and design; reference frameworks for modeling user needs within the context of wireless systems; user scenario creation and analysis; and user interaction technologies. This article provides an overview of WG1's work in these areas that are critical to ensuring that the future wireless world meets and exceeds the expectations of people in the coming decades.

Introduction

The application of science and engineering to mobile communications has been largely focused on technological issues such as developing technologies enabling radio access networks or terminal devices or engineering radio sites. As, until recently, voice has been the single dominant application for mobile communications, there has been relatively little need to understand the user and what he/she wants to do with the mobile service. Application of human factors principles or user-centered design has been limited to the ergonomics and usability of the terminal device, and in the study of usage patterns primarily for marketing purposes.

However, the mobile communications market is changing. Data services are beginning to gain traction worldwide, but particularly in Europe and Asia. 2.5G systems are being deployed to support more sophisticated data applications, such as web browsing and email. Third generation (3G) systems are going to be deployed soon, offering higher data rates to support more applications and greater capacity for data services. It will be critical to understand what people are going to use this capability for, and what they are prepared to pay for. There is a need to anticipate what broad application categories (such as video, email, browsing or m-commerce, etc.) will be important and also project what attributes will be most critical to optimizing the user experience of a particular application. These questions can be answered by utilizing user-centered design, which can identify underlying human needs and desires, the human value placed on any service and how to provide those needs given the limitations of the technology.

The Wireless World Research Forum (WWRF) is a forum whose stated aim is to build a vision of the future. It has recognized that the vision and technology of the future has to be defined by understanding the user. The Human Perspective Working Group (WG1) is a working group within the WWRF focused on discovering and promoting research areas that strive to understand the users' needs for future wireless systems and how users will interact with devices, systems and applications in the wireless world. An understanding of user requirements affords the opportunity to guide the research and development of applications, services and underlying technologies consistent with a primary goal of meeting user needs. The working group exists to gather inputs and views from industry

and academia, to synthesize these views to influence future visions and research priorities and to share results across the forum.

The subject matter scope of the Human Perspective Working Group includes all areas relevant to user needs for future wireless systems and the interaction of users with technologies embodied in these systems. Recently, the working group has concentrated its efforts in the following areas:

- Methods, processes and best practices for user-centered research and design
- Reference frameworks for modeling user needs within the context of wireless systems
- User scenario creation and analysis
- User interaction technologies

This article provides an overview of the issues and viewpoints in each of these four areas. In the limited space available, its not possible to do justice to the full descriptions of these topics. A more comprehensive treatment can be found in the collected whitepapers published as part of the WWRF Book of Visions 2003 [1].

User-Centered Design Process for Wireless Research

User-centered design (UCD) is practiced widely as a means to ensure that the user is considered in the design of products, systems and services. Rigorous processes that are well known in the design industry exist to support UCD. When considering how to conduct technological research for future systems, the concept of *user-centered research* can be considered. The basic benefit of applying user-centered research is that the technologies are not developed for their own sake, but to fulfill a user need or desire, thus maximizing the chance that technology research will be used in products and systems that people will use and thus build value in the marketplace.

User-Centered Design

User-Centered Design is a three-step process (Figure 1) incorporating the activities of a) deriving the requirements from analyzing the user and the context of use, b) following a structured design approach including prototyping against the user requirements and c) evaluating the design against the requirements. Note that the whole process is highly iterative and interrelated, as are the steps between the process elements, so that analysis, design and evaluation can be modified whilst the process runs.

During the ***analysis*** phase the characteristics of the users, tasks and the organizational and physical environment define the context in which the system is used. Structured analysis activities incorporate the following most important steps: user analysis, task analysis, environment analysis and comparative analysis. Examples of techniques typically used during the analysis phase are contextual enquiry models, focus groups and scenario based interviews, external data gathering and constraints analysis.

During the ***design*** phase a well structured design process supports the user orientation of wireless systems development. A large amount of qualitative knowledge exists and can be applied from the fields of human-computer interaction, cognitive ergonomics and other disciplines. In particular the mobile communications field has been very active in providing

user interface guidelines. Examples of techniques typically used during the design phase are conceptual design, paper prototyping, Wizard of Oz prototyping, computer based prototypes and physical prototypes.

During the ***evaluation*** phase the design solutions are assessed and feedback is given with two objectives; to identify usability issues and to assess the degree to which the user requirements of the analysis phase are met. There are many evaluation methods such as 'walk throughs', iterative prototype development, experimental study, subjective evaluation, usability study, functional prototypes, ergonomics and social impact studies that can be used as appropriate.

One widely adopted standard for UCD is the ISO standard ISO13407. This standard provides guidance on user-centered design activities throughout the life cycle of interactive computer-based systems. It is a tool for those managing design processes and provides guidance on sources of information and standards relevant to the user-centered approach. It describes user-centered design as a multidisciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and efficiency, improving human working conditions, and counteracting possible adverse effects of use on human health, safety and performance. The recommended process is shown in Figure 2.

Recommendations for User-Centered Research

ISO13407 is a particular instantiation of the three-phase UCD model described above. As such, it provides a valuable framework for applying these principles to user-driven research. Using ISO13407 and other models studied by WG1 (such as the KESSU model [?]), Figure 3 shows how the basic UCD model can be modified to suit research.

When applying UCD techniques to drive a research program, the following basic guidelines are recommended based on studying and extending currently available models.

1) The process reflects a top-down approach, preferably running in advance of the technology development. First steps should focus on eliciting user needs, wants and requirements from a technology agnostic perspective.

2) Next, define the requirements of broad technology areas from the user requirements. This translation from user requirements to technology requirements would typically go through the phases of translating:

   - User requirements into system requirements
   - System requirements into a systems architecture or reference model
   - System architecture into requirements on the elements that make up the system

3) User-centered methods can then be used within a multi-disciplinary technology development area, using the broad technology requirements to gain an understanding of technological capabilities and how they may or may not meet user needs.

4) Based on this understanding, design solutions that meet user requirements can be developed.

5) Design solutions should be prototyped to enable user evaluation.

6) The prototype technologies should be brought together into a systems test bed either by implementation or emulation of their capabilities.

7) Through evaluation of design solutions and test beds, requirements, design and technology development can be refined in response to user needs.

A user-focused reference model

It has been a goal of the Wireless World Research Forum (WWRF) to formulate a research framework and reference model for systems beyond 3G. In order to contribute to the formulation of a comprehensive reference model WG1 sought to develop a model from the perspective of the wireless user of the future. Based on the results from WG1 workshops, WWRF conference submissions and drawing on a catalogue of requirements and critical capabilities derived from user-focused scenarios[1], a reference model consisting of two planes has been proposed (Figure 4). The two planes offer the opportunity to reveal characteristics at different levels of abstraction relevant to a user-centered view of wireless systems. The value plane addresses the core human needs, such as safety that products and systems need to satisfy. Addressing these core needs demands that certain functionalities exist in the system capability plane. The system capability plane in turn places requirements on the system, e.g. applications and services needed to realize the capabilities. For example, a model developed by WWRF Working Group 2 [3] or the Cyberworld model [4] provide alternative ways of representing the applications and services aspects referenced by this model.

The structure of the model provides a framework for describing the characteristics of each component focus area and its relationship to other components using an adaptation of the format and formalism of the User Environment Design (UED) model as described by Beyer and Holtzblatt [5]. In its fullest detail, the proposed reference model provides the following descriptive elements for each component:

Purpose: a brief description of the scope of the focus area.

Functions: a description of the linkages to capabilities required in lower layers of the reference model.

Dependencies: an illustration of the relationships between the model components, for example complementary (e.g. context adaptation and personalization) areas or potentially conflicting (e.g. belonging and privacy) areas.

Constraints: key assumptions that influence the model.

Issues: a listing of critical issues that need to be resolved through future research.

Value Plane Overview

The value plane of the model describes the core human needs that wireless systems must satisfy (or at least not degrade) in order to be successful. The choice of values is based on Maslow's [6] hierarchy of human needs, a well-established theory of human behavior

[1] More detail about this scenario analysis is available in the next section.

which is widely used by product and marketing strategists. Weighting of values will vary across application contexts, and in some cases, values may conflict with each other (e.g. safety and privacy). Initial analysis has indicated that these core needs can be grouped into six focus areas:

Safety: Safety is the most basic human need, including both physical safety and mental well-being. Wireless devices, applications and services must be safe to use, but how wireless technology can provide or enhance safety of persons or property should also be considered.

Belonging: Belonging relates to the need for communication and relationships with others. In addition to traditional person-to-person communication, future wireless systems will need to support a variety of group activities and social networks.

Control: Not feeling "in control" is a state that causes distress and anxiety in most people. Ubiquitous information and communication access, while offering many potential benefits, present potential threats to human perceptions of control.

Privacy: Wireless technology and services create a wealth of data that can be used to – intentionally or unintentionally – invade the privacy of individuals or groups. In the design of any new application or service, the privacy implication of data generated and its access must be considered.

Self-Actualization: When basic needs are taken care of, most people look to achieve and create. Communications can present an important tool for those wishing to express themselves and share that expression with others.

Human Capability Augmentation: This notion implies that technology should amplify, enhance, or develop human capabilities – physical, mental, or social. Applications and services should aim to substitute when such capabilities are below par, or to enhance human capabilities (e.g. memory).

Capability Plane Overview

Meeting the needs of the value plane demands that the system provide a set of basic functionalities to the user. These basic capabilities need to be refined as part of the design process. These capabilities have been grouped into six focus areas:

Ubiquitous Communications and Ubiquitous Information Access: Ubiquity is a common theme across the first two capabilities. Ubiquitous communications foresees the development of communications devices embedded in everyday artifacts, making anytime/anywhere communication possible. Ubiquitous information access anticipates that information should be available for use by services, users and autonomous agents independent of the application or interaction device in use.

Context Adaptation: Context is information that can be used to characterize the situation of an entity (person, location or object). Context adaptation is about adapting the capability of a service, device or the communication network and information to elements of context information.

Personalization: Personalization is closely related to context adaptation, where the aim is to tailor a service or device to the personal preferences of an individual user. Concepts

such as ambient information, content filtering, user profiles and adaptation to terminal capabilities play an important role in achieving this goal.

Natural Interaction: In the rich communication fabric anticipated for the future wireless world, there is a need to encapsulate the underlying, often complex, technology with intelligent intuitive interfaces. The focus on natural interaction anticipates an extension of traditional user interfaces to include new technologies and leverage more of our human senses.

Presence Awareness: Presence awareness is a form of social awareness, providing in the context of communications a more or less detailed representation of other persons involved in the session. This capability affords the opportunity to significantly enhance the quality of individual and group communications.

User scenarios for the wireless world

Increasingly over the past several years, manufacturers, carriers, analysts and various industry pundits have offered visions of the future of mobile communications. These scenarios have been generated both for demonstration purposes and for assigning values to visions of cultural innovation. In both circumstances, scenarios can be considered tools that help to manage the technological innovation at different levels of project development. They are helpful to create cohesion around innovation perspectives, by making appeal to shared cultural values and user requirements. The analysis of scenarios can play a powerful role when it is used as a way to iteratively increase awareness on current technological limitations and on emerging patterns of behaviors within the user population.

An engineering approach for the management of scenarios might involve three phases: Scenario Generation, Scenario Prototyping and Scenario Evaluation. With the availability of many existing scenarios, WG1 has not concentrated on generating yet another set of scenarios for the wireless world. Instead, the focus has been on analysis of scenarios, attempting to find patterns and draw conclusions from what has already been described. What are the implications of what has been proposed: what technology requirements are suggested? Is there opportunity to define common methodological grounds for scenario generation and evaluation? Therefore, the following tasks were considered:

- a survey of the more user-centered visions that have been proposed for the wireless world, and
- an exploration of ways to analyze these scenarios to derive key technological requirements.

Scenario Catalogue

In the vast body of existing scenarios, there exists a dearth of “validated” scenarios, i.e. scenarios based on real user data. Further, little thought has evidently been given to how communications might fundamentally change with new systems. In contrast, scenarios do exist that go beyond what’s anticipated for 3G. Sources for such scenarios, chosen for further analysis, include the following:

ISTAG - The Information Society Technologies Advisory Group (ISTAG) provides a European viewpoint on future services related to ambient intelligence [7].

Mobile IT Forum - The Mobile IT Forum, an industry consortium sponsored by Japan's ARIB, has developed scenarios in the rather unconventional form of cartoons.

Project MESA - Project MESA (Mobile broadband for Emergency and Safety Applications) is a joint ETSI/TIA effort aimed at the future of public safety communications.

MIT Project Oxygen - This project, housed in MIT's Laboratory for Computer Science, is about "bringing abundant computation and communication, as pervasive and free as air, naturally into people's lives."

NTT DoCoMo "Vision 2010" - As part of a far-reaching corporate strategic plan, NTT DoCoMo have assembled an extensive video scenario set entitled "Vision 2010".

University of Oulu CyPhone – CyPhone is an interdisciplinary project, located at the University of Oulu in Finland, focused on a hybrid wearable computer/smartphone.

Scenario Analysis

As the scenarios we took into consideration show few commonalities and a large set of unique features, we were not able to define a framework common to all of them. Therefore, we thought that in order to achieve that outstanding result and for the sake of future research in the field, a set of guidelines might be recommended. We believe that by using these guidelines, it is possible to single out differences between the current socio-technical status and a future vision described by means of the scenario. These differences highlight relevant and significant changes from the user(s) perspective. The recommended guidelines include:

- A scenario should suggest why the changes will be acceptable to the user(s).
- Key actors and roles within a group or community should be identified so to emphasize different points of view.
- A scenario analysis should put into evidence the inter-dependencies among technologies in dynamic situations and contexts of use.
- The analysis should be a creative exercise and therefore it should benefit from collective thinking.
- People external to its development should validate the scenario according to representative criteria.
- A scenario analysis should foresee the most convenient way to represent data, results, and hypothesis.
- The analysis should produce a set of requirements.
- Finally, a scenario analysis should incrementally specify the proper level of detail. In other words, beyond the definition of requirements, it should also trigger data collection.

We believe that further guidelines are necessary in order to make compatible the visions that usually lay in the background and inspire new scenarios. Scenarios are a simplification of visions and lend credibility to them. By building scenarios upon a larger set

of guidelines, we could aim at a cohesive wireless world, where different visions could be harmonized.

User Interface Technologies and Techniques

In the field of mobile communications, two conflicting trends can be observed: the variety and complexity of wireless devices increase while the spectrum of users broadens. This means that more and more technologically inexperienced users must deal with devices, the operation of which gets more and more difficult due to their shrinking size and increasing number of features. The only feasible way to resolve this conflict is the improvement of the user interface (UI). In particular, the following requirements can be identified for user-friendly wireless devices of the future:

- robust, natural communication channels such as speech and mimics that work on any wireless device,
- an intuitive configuration (look and feel) based on meaningful interaction elements such as icons and sounds, and
- interfaces matching the individual preferences of each user group.

Natural communication channels

Currently, the UI of devices such as mobile phones, PDAs, webpads, etc. is restricted to keypads and touch-screens for the input and text/images or simple sounds for the output of information. The disadvantages are obvious: while it is already difficult to enter text on a miniaturized keyboard, it is impossible to do this in a hands-free situation. Also, it is very hard to read large amounts of text (e.g. a web-page) on the small screens of today's wireless devices. One way to overcome this problem is the implementation of speech as a channel for information exchange. Some manufacturers have already implemented simple keyword-based speech-recognizers in their products and some navigation systems use an artificial voice to guide car drivers. However, further research is mandatory as the robustness in terms of speaker-independence and noise tolerance is still too low and the vocabulary is limited. One way to increase the robustness of speech recognition for wireless devices is the integration of other communication channels such as lip-reading and mimics (i.e. facial expression) recognition, exploiting the redundancy between audio and visual channels in the same way as in human-to-human conversations. Taking into account the user's context can further increase ease of use and efficiency. For example, *a virtual personal assistant* [8] could search the internet for websites containing some desired information, providing only the currently important information to the user via a text-to-speech translation. Finally, the integration of many different communication channels increases the usability of the devices for impaired or disabled users. Summarizing, research bodies and companies working in the domain of mobile communication must intensify their efforts on integrating multiple natural communication channels to improve the user interface.

Intuitive UI elements and configuration

The frequent introduction of new services, new devices and new features increases the complexity of operation such that many customers use only a small subset of the features. Ideally, the operation would be harmonized across devices and services such that no re-

learning is necessary when changing the device. A first step is to use intuitive, recognizable interaction elements and shortcuts such as icons and earcons (characteristic sound signals) that are associated with common functions independent of the specific device [9]. Harmonized UI elements can also help impaired, elderly or infant users to operate the devices. Improving ease of use for the process of configuring a device or service according to one's individual preferences is also important and could be enabled in part by making personal preferences and data easily portable between devices. Again, co-operation of research institutions and manufacturers would be required to define and standardize UI elements in future wireless devices.

User Segments

The large majority of users are not interested in the technical details of the wireless devices but in their usability, efficiency, robustness, design and entertainment qualities. Although most users consider these aspects mandatory, their relative importance varies among customer groups. As such, the group-specific preferences must be taken into account during the process of UI design. For example, one approach [10] might consider three large user segments:

1) ***teenage users:*** In this group, the usage of wireless services, voice and data is very intense in particular for entertainment and communication services like SMS, downloadable games, chat, and email.

2) ***parental users:*** This group puts greater emphasis on seamless communication, the balance between home and job, the simplification of routine tasks (e.g. through wirelessly controlled "intelligent houses"), family management and self-realization.

3) ***professional users:*** This group, the financially most powerful group, demands solutions that facilitate their professional goals. Members of this group require personal information management, time management, email, internet access, seamless roaming, location based services, and online financial, travel and weather information.

To be successful in the wireless world, user interfaces will need to be tailored to their target users or be able to adapt to the different needs and preferences of the customer groups.

Conclusion

Considering the user in the vision of the wireless world will be critical to realizing the benefits of the vision for all interested parties (users, operators, manufacturers, etc.). The well-known principles of user-centered design provide a solid foundation, although some refinements and enhancements are appropriate to drive the user perspective in the early phase research that can drive the vision. By considering user needs in terms of both values and capabilities in a systematic way, there is the opportunity to link the user perspective on requirements to the more traditional view of system technical requirements. Scenarios provide an intuitive and powerful means to express user expectations in an evocative manner. Thorough analysis and evaluation of such scenarios holds the key to discovering where the compelling value lies and enumerating detailed user requirements. Finally, the user interface is critical as it represents the physical point at which the user engages with the technology. Interfaces of the future must leverage new technologies,

employ intuitive elements and engage users from multiple segments to drive to new levels of ease of use.

Acknowledgements

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Figures

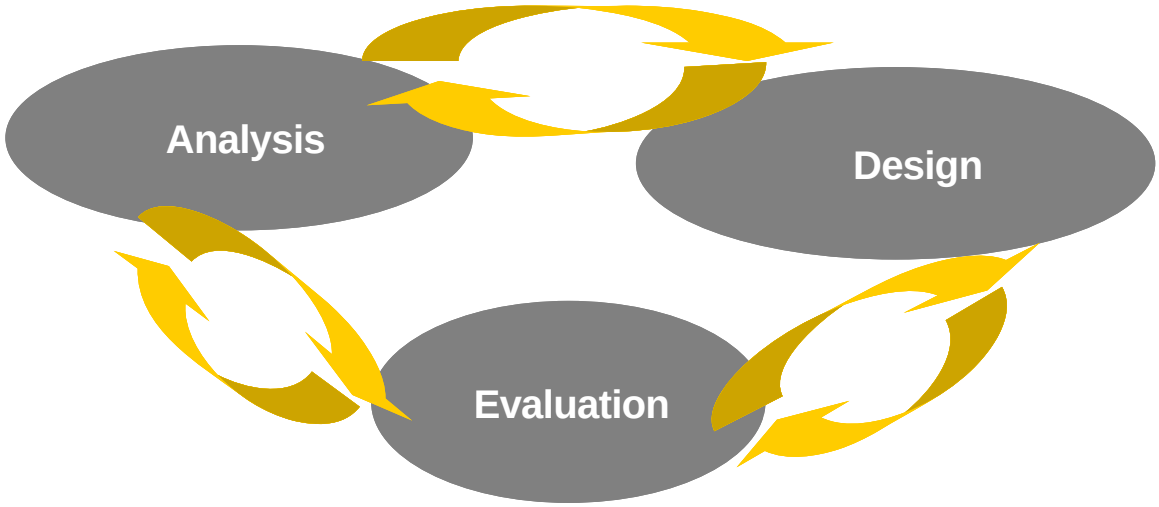

Figure 1: User-Centered Design Process

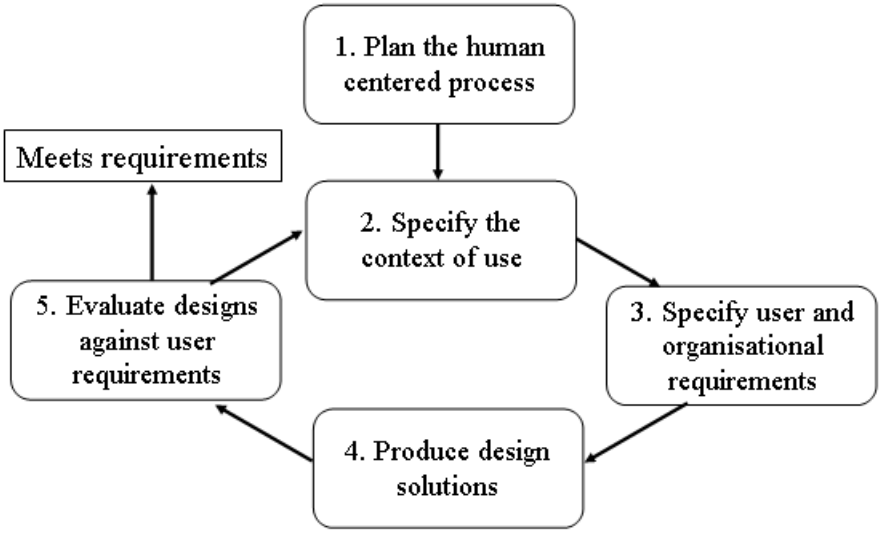

Figure 2: UCD process from ISO13407

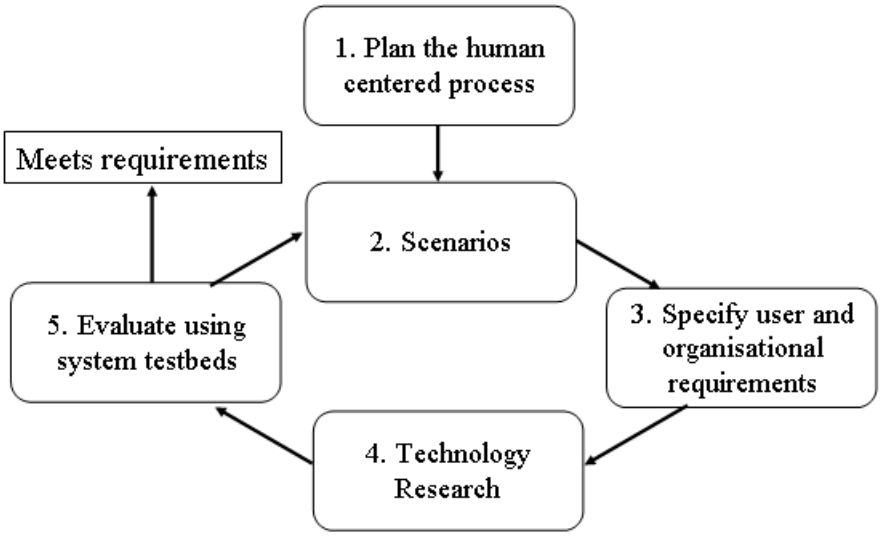

Figure 3: User-Centered Research Process

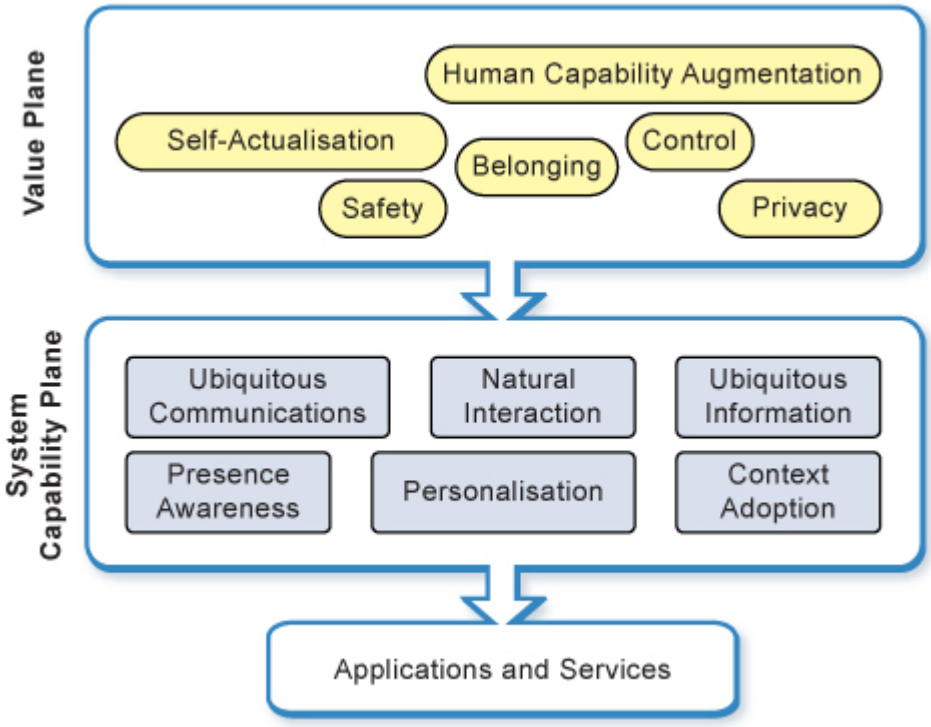

Figure 4: User-Focused Reference Model