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Technical Report

**Human Factors (HF);
Inclusive eServices for all;
Background analysis of future interaction technologies
and supporting information**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Human Factors (HF).

Introduction

As a response to the fact that new products and services are frequently being offered that do not take sufficiently into account the needs of people with mild or severe impairments, ETSI has published EG 202 848 [i.1] listing forthcoming user interaction technologies, and identifying for each technology likely accessibility issues and possible solutions that rectify those shortcomings.

The present document complements EG 202 848 [i.1] by providing additional information related to the approach taken for and results of that document.

In particular, the following issues are addressed:

- the focus of the EG on 'atomic' user interface technologies as opposed to higher-level user interaction concepts is explained;
- the application of the user interaction technology roadmaps is illustrated giving guidance on how to identify relevant user interaction technologies for any given eService;
- the approach for assessing accessibility issues of forthcoming user interaction technologies is explained;
- the question of inevitable insecurities in predictions and their outcome is addressed.

In order to identify user interaction technologies and Design for All solutions, a combination of data gathering and analysis methods has been applied, including:

- desktop research;
- specialist interviews and visits to company laboratories;
- workshops with stakeholders (e.g. representatives of organisations for elderly and/or disabled people, industrial key players and scientists);
- presentation of papers and information gathering at international conferences.

While the intention when developing EG 202 848 [i.1] was to establish findings with long-lasting applicability, continuing innovations in the field may require the updating of that document at a later stage.

1 Scope

The present document complements EG 202 848 [i.1] by providing additional information related to the approach taken for and the results provided by that document.

It explains the focus of EG 202 848 [i.1] on 'atomic' user interaction technologies as opposed to higher-level user interaction concepts, illustrates the application of the user interaction technology roadmaps identified in EG 202 848 [i.1], and explains the approach for assessing accessibility issues of forthcoming user interaction technologies.

Furthermore, the question of inevitable insecurities in predictions and their outcome is addressed and the combination of data gathering and analysis methods employed for EG 202 848 [i.1] are presented.

The guidelines mentioned in the present document are to be found in EG 202 848 [i.1] and are outside of the scope of the present document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EG 202 848: "Human Factors (HF); Inclusive eServices for all: Optimizing the accessibility and the use of upcoming user-interaction technologies".

[i.2] ITU-T Next-Generation Networks (NGN) Focus Group (FG). Proceedings. Part II. ITU, 2005.

[i.3] ITU-T Recommendation F.703 (2000): "Multimedia conversational services".

[i.4] ETSI EG 202 116: "Human Factors (HF); Guidelines for ICT products and services; "Design for All"".

[i.5] ISO/IEC TR 29138-1: "Information technology - Accessibility considerations for people with disabilities - Part 1: User needs summary".

[i.6] ISO/TR 22411: "Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities".

[i.7] Linstone, Harold L., Turoff Murray (2002): "The Delphi Method: Techniques and Applications".

NOTE: Available at http://is.njit.edu/pubs/delphibook/ (last visited: August 2010).

[i.8] OECD and Eurostat (2005), Oslo Manual: "Guidelines for collecting and interpreting innovation data", 3rd edition.

[i.9] Schumpeter, Joseph (1942): "Capitalism, Socialism and Democracy", Taylor & Francis e-Library, 2003.

[i.10] Schumpeter, Joseph (1965): "The Theory of Economic Development: an Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle", London, Oxford University Press.

[i.11] Utterback, J.M., Abernathy, W.J. (1975): "A dynamic model of process and product innovations", Omega, 3, 639-659.

[i.12] Edquist, Charles. (1997): "Systems of innovation approaches - their emergence and characteristics' in Edquist, C. (ed.) (1997) Systems of Innovation: Technologies, Institutions and Organizations", London: Pinter/Cassell.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

design for all: design of products to be accessible and usable by all people, to the greatest extent possible, without the need for specialized adaptation

eService: See service.

eService cluster: collection of multiple (electronic) services aggregating into one (joint, often more abstract) eService

eService component: constituent part of or set of eService functions that enable an electronic service (eService)

haptic: passive perception through the sense of touch

input modality: sense or channel through which a human can receive the output of an ICT device or service

EXAMPLE: Visual modality.

interaction modality: input modality or output modality

interaction technology: See user interaction technology.

modality: See interaction modality.

output modality: channel through which a sensor, device, or service can receive the input from the human

EXAMPLE: Kinesthetic modality.

service: complete capability, including terminal equipment functions, for communication between users, systems and applications, according to agreed protocols

tactile: perception through the sense of touch while actively moving parts of the body

user interaction technology: any instrument, equipment, or technical system enabling a user to interactively communicate with a device or service

user interface: physical and logical interface through which a user communicates with a device or service

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CSCW	Computer-Supported Co-operative Work
ICT	Information and Communication Technologies
OECD	Organisation for Economic Co-operation and Development
PSTN	Public Switched Telephone Network

4 Conceptual framework

The present document explains the conceptual background of EG 202 848 [i.1]. That document collects and lists guidelines for the user interaction design of ICT (information and communication technologies) devices and eServices that are likely to become available for large-scale rollout to consumers in the next five to ten years. In particular, that ETSI Guide identifies provisions that have to be made in order to ensure that forthcoming interaction technologies deployed in devices and eServices will be usable by all users including older people and/or people with impairments.

The scope of the technical roadmaps presented in [i.1] is focussed on user interaction technologies, i.e. technologies employed in the user interfaces of ICT devices for access to and delivery from eServices.

Figure 4.1 illustrates the conceptual framework and rationale for this approach. The underlying scenario is that of a user accessing an eService through ICT devices. In this scenario two distinct contexts can be identified:

- a user context which consists of the user with his or her intentions, abilities, and further characteristics; and
- a service context which consists of an eService with its characteristics and functional components, and the requirements that are put on the interface of the communication enabling device.

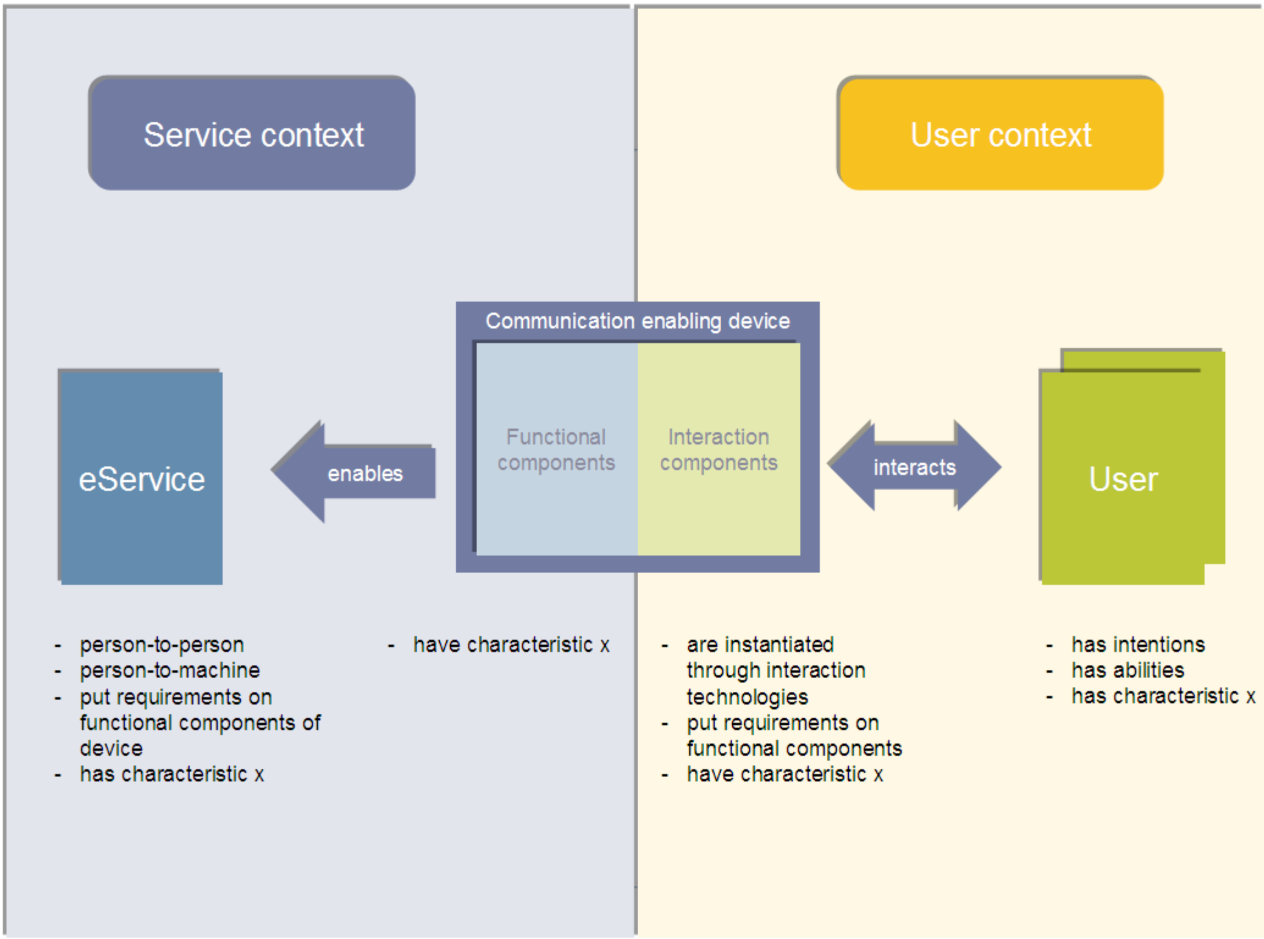

Figure 4.1: Conceptual framework of eService access

The communication enabling device itself mediates between those two contexts and can itself be divided into two separate groups of components, the functional components and the user interaction components.

The functional components comprise all software, hardware, and communication components enabling the eService with the exception of those 'atomic' components that make up the user interface and comprise the interaction components of the communication enabling device.

While a number of different levels of abstraction can be identified in describing user interaction (e.g. ranging from a simple button to a complex touch screen interface) the technology roadmaps in [i.1] focus on atomic user interaction technologies because:

- all upcoming user interaction concepts will consist of distinct configurations of those atomic user interaction technologies; and
- the characteristics of these atomic user interaction technologies strongly influence the accessibility of upcoming interaction concepts and thereby of the user interfaces of eServices.

It is worthwhile to mention that the usability and accessibility of user interfaces for eServices are affected by other user interface design issues (e.g. cognitive workload) which are not covered by the present document or [i.1].

5 From eServices to user interaction technologies

Inclusive eServices require accessible user interaction technologies. This clause explains in detail how eServices are related to future interaction technologies. This mapping process (see figure 5.1) consists of three steps:

1) Identification of current and future eService clusters, e.g. eLearning, their eService components, e.g. voice conversation, and their relationship.

2) Identification of user interaction modalities, e.g. audio input and audio output, and their mapping to eService components.

3) Identification of user interaction technologies, e.g. sound beam, supporting interaction modalities.

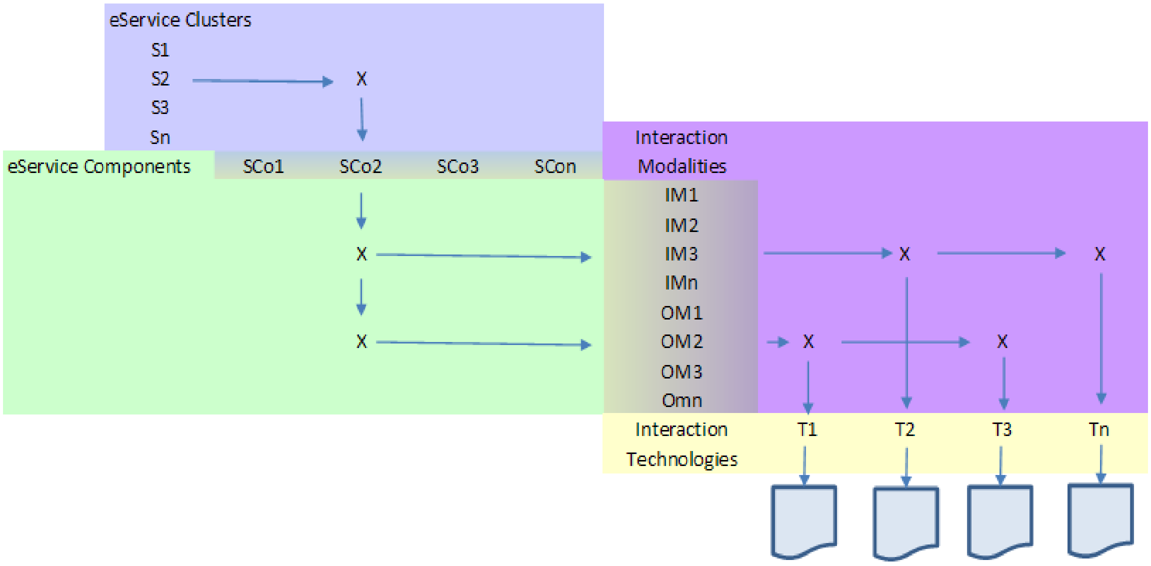

Figure 5.1: Relation of eService clusters to interaction technologies

The process of these steps is illustrated in figure 5.1. As a first step, current and future eService clusters (denoted "S1", "S2", …) are identified; each of these eService clusters is making use of one or many eService components (abbreviated "SCo1", "SCo2", …). These eService components comprise categories of telecommunications services such as total conversation, text telephony, and file sharing.

The second step starts off by identifying interaction modalities (in figure 5.1 shown as "IM1", "IM2", … for input modalities and "OM1", "OM2", … for output modalities). Following this, the previously identified eService components are mapped onto these interaction modalities.

It is now, as the last step, possible to specify interaction technologies ("T1", "T2", …) that support the interaction modalities identified and related to the eService components and eService clusters.

Readers who are interested in either a specific eService cluster or eService component may follow the process just described to identify applicable interaction technologies. A description of each of those interaction technologies is available in [i.1].

These steps are explained in greater detail in the following clauses. Each step in the process described is also annotated with a simple example to show how this process can be applied to the eService cluster of home automation services, more specifically to a smart homes eService.

5.1 eService clusters and their components (step 1)

The following list provides generally-accepted clusters of eServices and an explanation about the included services as examples. The eService clusters have been selected to cover a wide range of services:

- eGovernment services: eGovernment services include authentication services, electronic application for id-cards, passports, driver's licenses etc., remote payment of supplies like energy and water, as well as eTax services that include the electronic filing of tax forms, electronic payment of taxes, and communication with tax offices.
- eHealth services: eHealth services are, among others telecare services, remote health monitoring, access to patient data, remote diagnosis and electronic prescription services.
- Social services delivered through electronic means: Social services delivered through electronic means comprise remote supervision of people in need, ICT-supported caretaking (incl. robotics applications), social communities, electronic support for old people in need, messaging services, sharing services for pictures, video and music, ICT supported access to personalized human assistance.
- Home automation services: Home automation services supply services, energy management, light and entertainment management in the house, remote building control, or other "Smart Home" services.
- eBanking services: eBanking requires secure transmission and transaction services, remote authentication services as well as data- and secure information delivery to customers (e.g. for bank statements).
- Electronic purchasing services: Electronic purchasing services include and require electronic payment, authentication services, information and database search, and secure transactional communication, electronic travel booking and management, download of electronic content (music, video) and applications (app stores).
- Information services: Including news, sports results, and information retrieval.
- eLearning services: Remote access to school and university databases, virtual classrooms and remote teaching, remote access to museums.
- Mobile office applications and services: Mobile office applications include remote access to office data, Computer Supported Co-operative Work (CSCW) environments, electronic publishing services, remote translation services, messaging services, remote conference services, mobile email access, remote storage of personal data, etc.
- eGames and entertainment services: eGames and Entertainment comprise all sorts of interactive games played with remote partners of communication networks, delivery of information and entertainment content to customers, electronic pets, and remote support and monitoring of activities like exercising.

EXAMPLE 1: The eService cluster 'home automation' covers individual "Smart Home" eServices.

The eService clusters were analyzed to identify eService components (see table 5.1). For doing so, a classification produced by ITU [i.2] was adapted.

Table 5.1: Definition of eService components

Service components	Explanation
Person-to-entity communication	
Voice conversation	A connection and call that conveys only a speech component.
Total conversation	An audiovisual conversation eService providing bi-directional symmetric real-time transfer of motion video, text and voice between users in two or more locations (see [i.3]).
Instant messaging/chat	Peer-to-peer communications over the internet that may also provide the ability to make calls to the PSTN or to receive calls from the PSTN; differs from email primarily in that its primary focus is substantially immediate end-user delivery.
Text telephony	An audiovisual conversation service providing bi-directional real-time transfer of text and optionally audio between users in two locations. Audio may be transmitted alternating with text or simultaneously with text (see [i.3]).
Push to talk	Synchronous one-to-many voice messaging.
Telepresence	Task involving communication with or awareness of other users.
Multiparty communication	
Voice conferencing	Connection between two or more terminals, exchanging audio, text. and graphic information only.
Video conferencing	Connection between two or more terminals, exchanging audio, video, text and graphic information only.
Collaborative editing	Connection between two or more terminals for the joint editing of shared data.
Messaging	
E-mail exchange	Service to pass messages automatically from one computer user to another, often through computer networks and/or via modems over telephone lines.
Text messaging	Person-to-person text communication that is non-simultaneous.
Multimedia messaging	Person-to-person multimedia communication that is non-simultaneous.
Content-related applications	
Information browsing	Moving from place to place on the Internet searching for topics of interest.
Form filling	A process in which a user inserts data into a system-originated interactive form.
File sharing	File sharing is the practice of distributing or providing access to digitally stored information, such as computer programs, multimedia (audio, video), documents, or electronic books.
Application/data download/upload	Transfer of (executable) data between a network node and a server over a communication network.
Interactive digital broadcast	Digitally transmitted video or audio broadcast in combination with bi-directional communication means.
Context-related applications	
Identification-related applications	Applications and services based on the identity of a user or a group of users.
Presence/context-related applications	Applications and services based on data representing the status and availability of a user or a group of users.
Location-related applications	An information or entertainment service, accessible with mobile devices through the mobile network and utilizing the ability to make use of the geographical position of the ICT device.

EXAMPLE 2: Within an envisioned "Smart Home" eService (as part of the home automation eService cluster), two eService components will be developed: First, the presence of a user in the home will be sensed (presence/context-related and location-related application) and secondly, the Smart Home eService will also support multimedia messaging so that commands to the Smart Home can be given by voice.

This mapping (certain eService components as part of a specific eService cluster) is also depicted in table 5.2, i.e. both eService components (multimedia messaging and location-related applications) have an 'x'-mark under the eService Cluster of Home Automation.

With the identified eService clusters and the eService components, a mapping between these two has been produced (table 5.2). Table 5.2 illustrates typical functional patterns of each eService cluster. This mapping is helpful to either find relevant eService components for certain eService clusters, or vice versa.

Table 5.2: eService Clusters and Components

Service Components	eService Clusters									
	eGovernment	EHealth	Social services	Home automation	eBanking	Electronic purchasing	Information services	eLearning	Mobile office applications	eGames and entertainment
Voice conversation	x	x	x	x	x	x		x	x	x
Total conversation	x	x	x	x	x	x		x	x	x
Instant messaging/chat			x					x	x	x
Text telephony	x	x	x			x		x	x	
Push to talk			x							x
Telepresence		x	x					x		x
Voice conferencing	x		x					x	x	x
Video conferencing	x		x					x	x	
Collaborative editing								x	x	
E-mail exchange	x	x	x		x	x		x	x	
Text messaging	x	x	x	x	x	x	X	x	x	x
Multimedia messaging	x	x	x	x				x	x	
Information browsing	x	x	x		x	x	X	x		
Form filling	x	x		x	x	x	X	x	x	
File sharing			x				X	x	x	x
Application/data upload/download	x	x			x		X	x		x
Interactive digital broadcast	x		x					x		x
Identification-related applications	x	x	x	x	x	x		x		x
Presence/context-related applications		x	x	x		x	X	x		x
Location-related applications		x	x	x		x	X	x		x

5.2 Interaction Modalities and their mapping to eService Components (step 2)

In the second step of the procedure described above and illustrated in figure 5.1, the interaction modalities (input modalities and output modalities) are defined (see table 5.3), and then eService components are mapped onto the interaction modalities (see table 5.4).

Table 5.3: Definition of Interaction Modalities

Interaction Modality	Explanation from the user viewpoint
Input	
Acoustic/Audio	Generation of sounds and utterances
Kinesthetic	Sensation of movement
Presence/location/proximity based input	Interaction based on place (e.g. meeting room) or location
Recognition/mood/arousal based input	Interaction based on the recognition of an individual, their mood or level of arousal
Smell	Generation of smell
Touch	Actuation/sensation of touch
Visual	Visual presence/generation of optical signals
Output	
Acoustic/Audio	Perception of sounds and utterances
Haptic/Tactile	Sensation of touch and/or movement
Smell	Perception of system generated smell
Taste	Perception of system generated tasteable chemicals
Visual	Visual presence/optical signal perception

EXAMPLE: From the (previously identified) selection of supported eService components of the Smart Home eService it is easy to deduce what kind of modalities need to be designed for: The presence/context-related application eService component will make use of *presence/location/proximity based input* to inform the Smart Home about the presence of a user.

To enable the multimedia messaging (as eService component) the modality of *acoustic/audio input* will be provided for to allow the user to give voice commands to the system.

This can also be read out from the mapping between eService components and the likely applicable user interaction modalities (in table 5.4 below): Presence/location/proximity-related applications have an 'x'-mark under presence/location/proximity-based input and equally, for multimedia messaging an 'x'-mark can be found under the column for acoustic/audio input as interaction modality.

Table 5.4: eService Components and Interaction Modalities

Service Components	**Interaction Modalities**											
	Input							Output				
	Acoustic/ audio	Kinesthetic	Presence/ location/ proximity based	Recognition/ mood/ arousal based	Smell	Touch	Visual	Acoustic/ Audio	Haptic/ Tactile	Smell	Taste	Visual
Voice conversation	x							x				
Video conversation	x						x	x				x
Total conversation	x						x	x				x
Instant messaging / chat		x				x	x					x
Text telephony		x				x	x					x
Push to talk	x	x				x		x				
Telepresence	x	x					x	x		x	x	x
Voice conferencing	x							x				
Video conferencing	x						x	x				x
Collaborative editing	x	x				x	x	x				x
E-mail exchange		x				x	x					x
Text messaging		x				x	x					x
Multimedia messaging	x	x				x	x	x				x
Information browsing	x	x				x	x	x				x
Form filling		x				x	x					x
File sharing		x				x	x					x
Application/data download		x				x	x					x
Interactive digital broadcast	x	x				x	x	x				x
Identification-related application				x			x	x	x			x
Presence/context-related application	x		x	x	x		x					
Location-related applications	x		x				x					

5.3 Technologies supporting Interaction Modalities (step 3)

In the third and last step, forthcoming user interaction technologies have been identified and analyzed from an accessibility perspective in [i.1] where they have been grouped according to their supported interaction modalities.

With this step, the process of linking eService clusters to eService components, eService components to interaction modalities, and finally, interaction modalities to interaction technologies has been completed. One can now use different starting points, e.g. a certain eService cluster, to find and resolve accessibility issues when planning to make use of a future interaction technology.

EXAMPLE: With the (previously identified) modalities of audio input and visual input, it is possible to look up these modalities in [i.1] and find under clause 6.2 "Acoustic/audio input technologies roadmap", a personal microphone that can be worn like a brooch and seems to be suited to provide the user of a Smart Home eService with the ability to give voice commands (see figure 5.2).

For the location-related eService Component the modality of place/location input was looked up above: In [i.1], clause 6.4, "Presence/localization/proximity based input technologies roadmap" includes information about a passive infrared (PIR) sensor technology. It can sense "infrared (IR) radiation emanating from people in their field of view" and thus seems well suited to detect the presence of a user in a Smart Home eService.

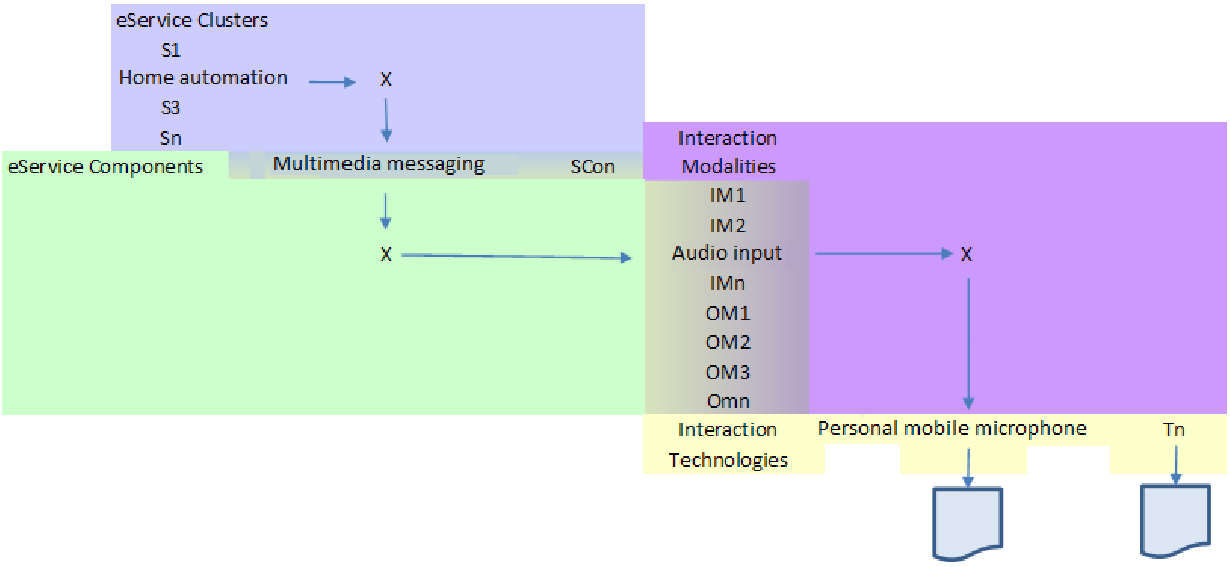

Figure 5.2: Example relation between the eService cluster "Home automation" and the interaction technology "Personal mobile microphone"

6 Assessing the accessibility of UI technologies

For most interaction technologies and user interface tasks, a number of different design solutions exist that differ in terms of their accessibility for groups of users with different abilities. Therefore, when developing new products, the recommended way to provide the optimum user experience is to always adopt a user-centred approach - starting from an analysis of user needs and introducing involvement of users with different ability profiles into all stages of design and testing. According to the Design for All philosophy, this is the most appropriate way to cover as many different user groups as possible. Furthermore, Design for All recommends that for those user groups who are not covered by the final design, standardised interfaces for assistive devices should be offered. The same could be said of innovative interaction technologies being designed and developed in laboratories, as they may become part of future commercial products.

There are many standards and guidelines that can be used to support a user-centred approach to the development of accessible products that utilise interaction technologies currently in use. The aim of user-centred development is to include a broad range of potential users. However, it is never possible to include users that have all possible forms of functional impairments (and combinations of impairments). To compensate for this, accessibility standards and guidelines that indicate additional requirements that should be addressed in the product development are used to influence the design.

However, when a new technology is used it may influence the user experience of a product in ways that have not been considered in existing guidelines and standards (i.e. those that were developed in the context of current, or older, interaction technologies).

Therefore, there is a need to make Design for All provisions for emerging interaction technologies. EG 202 848 [i.1] defines provisions that have to be made prior to or during the development and the introduction of each new technology, in order to enable the support of emerging services for users with disabilities. Standards on requirements and guidance about accessibility to ICT, such as [i.4], [i.5] and [i.6] provide a very coherent source of the accessibility requirements of ICT users. These sources have been used as the methodological framework when analysing the accessibility of new interaction technologies and styles. However, emerging interaction techniques pose interaction challenges that still remain unaddressed by generic standards. One of the reasons behind this may be that certain modalities (e.g. haptic/tactile) that receive an increasing importance in user interfaces have been traditionally used more as a complement to other modalities (e.g. visual and auditory) than as main interaction channels. [i.1] focuses, therefore, on ongoing research and standardisation activities which are specific to such modalities. Furthermore, a scientific review on accessibility aspects of emerging interaction paradigms (e.g. gesture recognition, virtual reality) has been carried out.

[i.1] seeks to highlight factors related to future interaction technologies that may enhance or degrade the user experience when the future interaction technologies are used in place of what is used in today's products. In addition, it proposes ways in which the product design could be altered in order to (fully or partly) nullify predicted degradations to the user experience. Emphasis is placed on the potential effect of future technologies on accessibility, where future user interaction technologies have the potential to increase the barriers already experienced by users with impairments, but also have the potential to remove barriers that are created by the limitations of today's interaction technologies.

In conclusion, Design for All and user-centred design should be an integral part of any development process of new interaction technologies. This requires that accessibility and e-inclusion be included in the quality plans and processes of manufacturers and laboratories, at the same level than other relevant, well-established parameters such as cost, power consumption, etc. These processes should follow a systematic iterative procedure, based on accessibility evaluation of prototypes. [i.1] has been produced with the aim of becoming part of the toolbox of such a user-centred approach to technology/product development where accessibility aspects of user experience are addressed.

7 Levels of uncertainty in future-related work

7.1 General

A question that recurred whilst attempting to specify the technology roadmaps of ICT eServices and products for the next decade (until 2020), when meeting with experts from different technology research and development fields to discuss (preliminary) findings, or when presenting them at different conferences, was "To what extent can we believe that these predictions will come true?".

Discussing this question is helpful as it provides the opportunity to explain both the approach taken and clarifying what delimitations we apply and are aware of. This clause gives some relevant background to such level of uncertainty in future-related work by pointing out general critique, theories and methodology of working with technology prediction, as well as assumptions that were employed. This clause represents a short introduction and explanation to the very wide field of future prediction, technology (or economic) forecasting and its relationship to innovation(s). The references provided may provide a starting point for further investigation for interested readers.

7.2 Study of the future: Proceed with caution!

Most experts will probably have come across historic predictions of the future (in their respective field) that have proven to be shockingly wrong in light of the actual developments. To take just a few examples, in a memo at Western Union in the 1870s it is claimed that "This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us"; Ken Olson, then president, chairman and founder of Digital Equipment Corp. (DECT), in arguing against the Personal Computer in 1977 is notoriously quoted as "There is no reason anyone would want a computer in their home". Such negative assessments are not the only type of blunders - equally known are what later appear as too optimistic predictions. Nuclear power and its beneficial usage is just one field where over-optimistic statements occurred: Alex Lewyt, then president of a leading vacuum cleaner corporation foresaw in 1955 that "Nuclear-powered vacuum cleaners will probably be a reality in 10 years".

Such citations are often used in a humorous way to show an awareness that any predictions today about the exact future within a domain stands a good chance of being ridiculed in the future. This also serves as a humble reminder of the uncertainty of the future and its prediction and planning for it. If the - then experts in their respective field could be so wrong about their assessment (always assuming that they truly believed in their statements themselves), those preparing the content of EG 202 848 [i.1] might not perform any better in predicting the development today. One can wonder about the many different forms and attempts to foresee future developments. What are the theoretical framework(s) that support such investigations such as white papers, strategic R&D or marketing roadmaps, (national and international) development of research agendas, sponsored research approaches in form of "Grand Challenges", postulation of future trends, projections of demographic developments and their consequences, or having expert consultation with help of a Delphi method [i.7]?

7.3 Development and Innovation as dynamic process

There are numerous disciplines making contributions to theories, models and methods that cover innovation or the relationship of design to product development. Some of the relevant concepts are briefly introduced to give an account of the theoretic perspective of the technology roadmaps created.

For the scope of the technology roadmaps we only focus on **product innovations**, i.e. while being aware of other forms of innovations (e.g. process-, marketing-, or organisation innovations) they are not addressed by our technology roadmaps. The OECD defines product innovation as:

"A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes **significant improvements** in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Product innovations can utilise new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies." From [i.8], p. 48, emphasis from the authors of the present document limiting the scope to the innovations judged to provide only the mentioned significant improvements as candidates.

Turning towards different patterns of innovations the work of Schumpeter needs to be mentioned: Already in 1942 [i.9] Schumpeter introduced the term *creative destruction* while investigating the role of innovations for organizations in the capitalistic economic system and the role of the entrepreneur, a process characterized by:

"[…] the opening up of new markets, foreign or domestic, and the organizational development […] illustrate the same process of industrial mutation that incessantly revolutionizes the economic structure **from within**, incessantly destroying the old one, incessantly creating a new one" [p.84, original emphasis]

Development is in Schumpeter's view [i.10] then a:

"[…] spontaneous and discontinuous change in the channels of the flow, disturbance of equilibrium, which forever alters and displaces the equilibrium state previously existing." (p. 64)

The importance from Schumpeter's understanding of development and creative destruction for anyone trying to anticipate technological developments is the attributes of an innovation, given [i.10], p.68 as:

"1) The introduction of a new good or a new quality of a good.

2) The introduction of a new method of production, or a new way of handling a commodity commercially.

3) The opening of a new market, or entry into an existing market by a new branch.

4) The conquest of a new source of supply of raw materials of half-manufactured goods.

5) The carrying out of the new organization of any industry."

Innovations are thus manifested by a new product ("good"), or in the present case [i.1] a novel interaction technology, or quality of a product that goes along with a new method (i.e. a new process or interaction); the importance of a (successful) market entry (i.e. the commercialization is an important part of **any invention turning into an innovation** - the term "foreseen mass market penetration" has been used), again triggering either the usage of new materials (or innovative combinations of already existing solutions), and last but not least, the likely organizational change that such innovations will bring about. In this definition and characterization of innovation effects, Schumpeter is still helpful in analysing potential future developments. For the technology roadmaps some of the attributes to investigate have been used e.g. the new quality as far as their importance to interaction technologies and accessibility is concerned.

From the 1970s onward the *incremental-radical innovation dichotomy* was put forward as Utterback and Abernathy [i.11] described the evolution of technology through periods of incremental innovations which are however interrupted by phases of change through so called radical innovations.

Two relevant dimensions can be described along this dichotomy between incremental and radical innovations: As incremental innovation builds upon existing knowledge it is said to act as *competence enhancing innovation*. The opposite (*competence-destroying*) happens instead with radical innovations which require completely new and different sets of competencies than previously needed.

The second dimension looks instead upon the different effect on the imposed technological change: incremental innovations only require small changes to existing products - radical innovations instead are likely to involve rather large advances in technology offerings - in effect making already existing products obsolete.

The considerations above suggest that innovation needs to be understood as complex process that is embedded in a multifaceted network of relationships. Edquist [i.12] thus uses the term *system of innovation* to describe:

> "all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations." (p.14)

With this brief introduction to "innovation" as a complex and dynamic phenomenon, it has hopefully become evident why attempting to predict if, when and why an invention (i.e. a discovery or finding) might turn into an innovation, is a task with a high level of uncertainty.

8 Outlook / future work

As identified in clause 7, there is an inherent level of uncertainty in identifying which future user interaction technologies will be available in the mainstream mass market over the next five to ten years. In addition, identifying the dates at which such technologies will enter mainstream usage is also recognised to be an inexact science. EG 202 848 [i.1] attempts to present the best available view that could be achieved, at the date at which the underlying research was completed, of what technologies will be relevant and when they may emerge.

What is certain is that, almost immediately [i.1] is published, the expectations of which technologies will reach the marketplace and when they emerge will begin to change. These changes can be in the form of a gradual understanding that the development and deployment processes behind a certain technology may lengthen or shorten according to external factors such as a gradual change in the market for the related products or an increase or decrease in the costs of the materials or processes necessary to fabricate the technologies. During consultation with ICT experts from industry the exact timing of mass market penetration was also contested for certain technologies. These experts commented that novel technologies might first only be made available in the high-end of product and service offerings before "trickling down" to mainstream offerings, the exact timing being dependent upon many difficult to foresee factors (such as product diversification in the market, pressure from competitors or strategic decisions how to develop the market share). However, such changes would only result in some minor movements in the positioning of the already identified technologies on the technology roadmaps that are shown in [i.1]. This would mean that most of the roadmaps would continue to be of use in understanding the future of the group of technologies associated with any user interaction modality represented by the roadmap. These changes in the timescales of technology deployment should, in themselves, have no impact on the validity of the information contained in the technology properties tables presented in [i.1].

There may also be gradual changes in the way that the user interaction technologies are actually realised, and these may potentially cause some of the information in the technology properties tables to become less correct. However, it is likely that, for the normal changes that occur as technologies smoothly develop, the majority of the information in the technology properties tables will still be very relevant and that the cases where something has changed will often be self-evident.

Where the information in [i.1] will gradually become less representative of the current state of the art is where new user interaction technologies emerge that were not predicted in [i.1]. Where these technologies are very similar to those already described in [i.1], the technology property tables should still prove very valuable in predicting most of the benefits, barriers and solutions that might apply to the newly emerging technology. Where the new technologies are truly unique and quite unlike any of the technologies addressed in [i.1], the only source of guidance that can be used to help predict benefits, barriers and solutions are by reference to the "Key Design for All solutions" identified in clause 6.1.3 of [i.1].

All of the above arguments show three things:

1) The nature of the structure and content of EG 202 848 [i.1] is such that it can maintain a high level of usefulness in addressing the natural gradual evolution of the understanding of the user interaction technologies addressed. Both the technology roadmaps and the technology property tables have a degree of robustness in terms of preserving their usefulness as the understanding of the technologies gradually evolves.

2) Where new technologies emerge that were not predicted in [i.1], two possibilities emerge. Where they are similar to other technologies in [i.1] the related technology properties table is still likely to be of significant use. Where the newly uncovered technology is truly unique, the "Key Design for All solutions" are the only part of [i.1] that may be of use.

3) In all situations it is certain that the relevance and usefulness of [i.1] will steadily decrease over time.

In order to ensure that the value in [i.1] is preserved, it will be necessary to regularly update the document to ensure that it correctly reflects the most recent understanding of which technologies are likely to appear within five to ten years, how they are likely to emerge (shown on revised roadmaps) and what benefits, barriers and solutions relate to them (shown in new and revised technology properties tables).

History

Document history		
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