Toward an Information Society for All: HCI challenges and R&D recommendations

Workshop Chairs

Constantine Stephanidis
FORTH-ICS, Greece

Gavriel Salvendy
Purdue University, USA

Secretary
Demosthenes Akoumianakis
FORTH-ICS, Greece

Albert Arnold
Delft University of Technology, The Netherlands

Nigel Bevan
National Physical Laboratory, UK

Daniel Dardailler
W3C/WAI, France

Pier Luigi Emiliani
IROE-CNR, Italy

Ilias Iakovidis
Telematics Applications Programme, European Commission

Phill Jenkins
IBM Special Needs, USA

Arthur Karshmer
Computer Science Department, New Mexico State University, USA

Peter Korn
Sun Microsystems Inc., USA

Aaron Marcus
Aaron Marcus and Associates Inc., USA

Harry Murphy
Centre on Disabilities, California State University, USA

Charles Oppermann
Microsoft Corporation, USA

Christian Stary
University of Linz, Austria

Hiroshi Tamura
Kyoto Institute of Technology, Japan

Manfred Tscheligi
University of Vienna, Austria

Hirotada Ueda
Hitachi Denshi Ltd., Japan

Gerhard Weber
Harz University, Germany

Juergen Ziegler
Fraunhofer IAO, Germany

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Requests for reprints should be sent to Constantine Stephanidis, Institute of Computer Science (ICS), Foundation for Research and Technology - Hellas (FORTH), Science and Technology Park of Crete, Heraklion, Crete, GR-71110, Greece. E-mail: cs@ics.forth.gr

This article reports on the results of the second meeting and workshop of the International Scientific Forum "Towards an Information Society for All", that took place in Crete, Greece, June 15-16, 1998. In particular, it elaborates on the international Research and Development (R&D) agenda [published as a White Paper in the International Journal of Human-Computer Interaction, Vol. 10(2), 1998, pp. 107-134], which resulted from the first meeting and workshop of the Forum in San Francisco, California, USA, August 29, 1997, in the context of the HCI International '97 Conference. The present document elaborates on the proposed R&D agenda by identifying Human Computer Interaction (HCI) challenges and clusters of concrete recommendations for international collaborative Research and Technological Development (RTD) activities. Four clusters of recommendations are proposed, of which the first three are intended to facilitate reaching technological targets, while the fourth comprises accompanying measures. The three technological clusters are related to the corresponding transitions from: (a) productivity tools to environments of use; (b) individual users to communities of users; and (c) computer-assisted business tasks to computer-mediated human activities. The fourth cluster covers support (horizontal) actions needed to establish a favorable environment for the creation of an Information Society acceptable to *all* citizens. Each cluster is elaborated by means of specific recommendations, plausible RTD objectives and likely or expected outcomes.

1. INTRODUCTION AND BACKGROUND

The International Scientific Forum (ISF) “Towards an Information Society for All” is a network for collaboration, discussion, and exchange of experience and practice on the broad range of issues related to the accessibility, usability, and ultimately the acceptability of the emerging Information Society. The objective of the International Scientific Forum (ISF) is to promote the establishment of a favorable environment for the creation of an Information Society acceptable to *all* citizens.

Information Society refers to the new status quo and the new socioeconomic and technological paradigm likely to occur because of the current all-embracing process of change. It is expected to affect the interaction in computer-mediated human activities, individual human behavior, the collective consciousness, and the economic and social environment (Stephanidis et al., 1998). The emergence of the Information Society signifies the transition toward a new form of society based on the production and exchange of information (see Figure 1), as opposed to physical goods. Its evolution is likely to introduce new virtual spaces (Winograd, 1997) and a whole range of computer-mediated human activities (Nardi, 1996).

In this context, the ISF aims to promote *universal design* in Information Society technologies, emphasising *accessibility* and *high quality of interaction* by the broadest possible end-user population, including people with special needs. *Information Society Technologies* refers to innovative technologies that drive the emergence of the Information Society, either as a result of incremental demands on behalf of the customer base, technological breakthroughs, or fusion-type innovation. The primary industry sectors that generate and push the development of these technologies are the information technology, telecommunications and media sectors.

Universal design or *design for all* (here used interchangeably) has different connotations. For some individuals, it is considered as a new politically correct term, referring to efforts intended to introduce “special features” for “special users” during the design of a product. To others, universal design is a deeply meaningful and rich topic that elevates what designers like to call “good user-based design” to a more encompassing concept of addressing the needs of all potential users. In this article, the phrase is used to reflect a new concept, or philosophy for design that recognises, respects, values and attempts to accommodate the broadest possible range of human abilities, skills, requirements and preferences in the design of all computer-

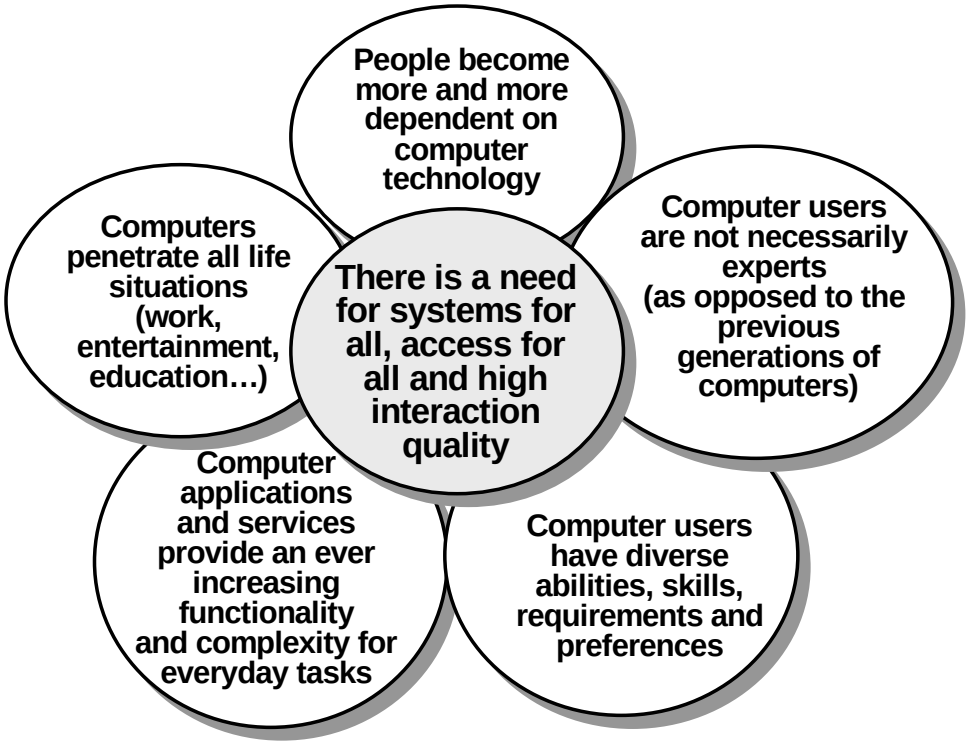

Figure 1: Critical trends towards the emergence of an Information Society

based products and environments. Thus, it promotes a design perspective that eliminates the need for "special features" and fosters individualisation and end-user acceptability (Stephanidis et al., 1998; Story, 1998). As already pointed out, *universal design* is used interchangeably with *design for all* users. This does not imply a single design solution suitable for all users. Instead, this interchangeability should be interpreted as an effort to design products and services, in such a way, so that they suit the broadest possible end-user population. In doing so, different solutions for different (categories of) users and different contexts of use are more likely to emerge.

Accessibility, on the other hand, traditionally has been associated with disabled and elderly people (Bergman and Johnson, 1995; Muller et al., 1997) and reflects the efforts devoted to the task of meeting prescribed code requirements for use by people with special needs (Story, 1998). However, due to recent technological developments (e.g., proliferation of interaction platforms, such as wireless computing, wearable equipment, and user terminals), the range of different categories of users, that may gradually be confronted with accessibility problems, extends beyond the population of disabled and elderly users (National Research Council, 1997). In this article, *accessibility* denotes the global requirement for access to information by individuals with different abilities, skills, requirements and preferences, in a variety of contexts of use (International Standards Organization [ISO], 1997). Its meaning is intentionally broad, so it encompasses accessibility challenges that *diversity* posses in (a) the target user population (including people with special needs) and the individual and cultural differences, (b) the scope and nature of tasks (especially as related to the shift from business tasks to communication and collaboration intensive computer-mediated human activities), and (c) the technological platforms and associated devices through which information is accessed.

Finally, the notion of quality in use, is typically associated with various meanings and connotations (Garvin, 1984; Bevan, 1995; Bevan and Anzuma, 1997), and the ways it can be achieved as part of the production process also vary (e.g. ISO, 1987; ISO, 1994). In this article,

quality entails the consideration of a broad range of functional (e.g., domain specific qualities, such as interoperability and search efficiency) and non-functional attributes (e.g., portability, scalability, modifiability), which affect the use of information artefacts by humans, in their various problem solving, information seeking and communication intensive computer-mediated activities. This notion of quality goes beyond the traditional concept of usability (i.e., measurable attributes based on performance criteria such as effectiveness, efficiency, satisfaction, etc), to include aspects (such as usefulness, suitability for task, tailorability, etc) which may not be measurable with currently available means.

The aims of the first ISF meeting and workshop in San Francisco (Stephanidis et al, 1998) were to (a) assess the state of the art in the area of accessibility and universal design, (b) stimulate new developments, and (c) advance the existing wisdom towards universal access and high quality interaction in the emerging Information Society. The specific objectives were:

- To identify, consolidate and characterise progress in the relevant scientific fields and develop a short-, medium- and long-term research and practice agenda towards an Information Society accessible and acceptable by *all* citizens.
- To stimulate support measures required at national and international levels in order to raise awareness, achieve consensus, promote work in the relevant fields and establish a favourable environment for the creation of an Information Society for *all* citizens.

Following this meeting, the ISF produced a White Paper entitled *"Toward an Information Society for All: An International R&D Agenda"* (Stephanidis et al., 1998), which introduced the goal of an Information Society for *all* citizens, and proposed a short-, medium-, and long-term international R&D agenda, based on the principle of designing for *all* users. The proposed agenda addresses technological and user-oriented issues, application domains and support measures, which are deemed as necessary for the establishment of a favourable environment for the creation of an Information Society acceptable to *all* citizens.

The focus of the second ISF meeting[1] in Crete was more narrow in scope, aiming to elaborate, review and consolidate the outcome of the first ISF meeting, as reported in Stephanidis et al. (1998). This was approached in the context of four themes related to *HCI design*, *usability*, *user interface software technologies*, and *standardisation*, as well as in connection to their relevance with respect to accessibility and universal design. For each of these topics, the goal of the workshop was to develop concrete recommendations which would result in influential interventions, anticipated to expand the current scope of R&D activities and support measures in the direction of *universal access* and *high quality of interaction* for *all* citizens in the Information Age. The deliberate intention to address the above HCI-related topics is based upon the critical role of this technology in shaping the type, range and scope of computer-mediated human activities in the emerging Information Society. It is anticipated that in future,

[1] The meeting was organised as a roundtable discussion co-ordinated by the Chairman. Secretarial support was also available. A draft agenda was provided in advance as part of a background document. Minutes of the meeting were kept by the Secretary and were distributed to all participants shortly after the meeting. Each participant actively contributed to the selected thematic topics of the meeting. Each thematic topic was explored in a sequence of four phases (a) review, (b) short presentations (position statements), (c) user issues, and (d) discussion and consolidation. Participants came from Europe (12), USA (7) and Japan (2). The research community was represented by academics (9) and researchers (7). Industrial participation included four (4) large Information Technology actors and one (1) small-size enterprise. All participants are senior professionals within their organisation and some of them participate in international standards committees and are heavily involved in trans-national collaborative activities.

follow-up meetings, the ISF will progressively address additional relevant topics, as emerging technologies mature and become embedded into new products and services.

2. R&D ROADMAP - AN OVERVIEW

2.1 Consolidation

As already pointed out, the second ISF meeting focused on accessibility as related to four primary themes, namely HCI design, usability, user interface software technologies and standardisation. In this context, *accessibility* was defined as the global requirement for access to information, communication and social interaction by individuals with different abilities, requirements and preferences, in a variety of contexts of use. Thus, the meaning of the term is intentionally broad to encompass accessibility challenges as posed by diversity in

- The target user population (including people with special needs) and the individual and cultural differences.
- The scope and nature of tasks (especially as related to the shift from computer-assisted business tasks to residential and social computer-mediated human activities).
- The technological platforms and associated devices likely to penetrate the emerging broad range of computer-mediated human activities.

Following reviews by participants and discussions pertaining to each one of these topics, several recommendations were compiled regarding future R&D activities. In total, over 50 recommended research items were identified in the context of the four themes of the workshop. These items interrelate and give rise to certain clusters that highlight the group's visionary targets to be met en route to an Information Society. Four main clusters were identified and include recommendations regarding *software technologies*, *users*, the *scope of usage*, and *accompanying* or *support measures*.

Figure 2 highlights some of the targets that R&D has facilitated until now, as well as the new potential targets that should be facilitated in the future. The clusters reflect the progressive shift from an Industrial Society towards an Information Society, as well as the expected / desirable transition in terms of the objectives, for each of the three dimensions. In addition to the three clusters, and the corresponding targets depicted in the diagram of Figure 2, the ISF stressed the importance of accompanying measures (or supporting actions) as a fourth dimension relevant to the evolution of an Information Society for *all* citizens. This fourth dimension is orthogonal to any particular sector, or application domain, and reflects global requirements for the establishment of a favourable environment for the envisioned Information Society.

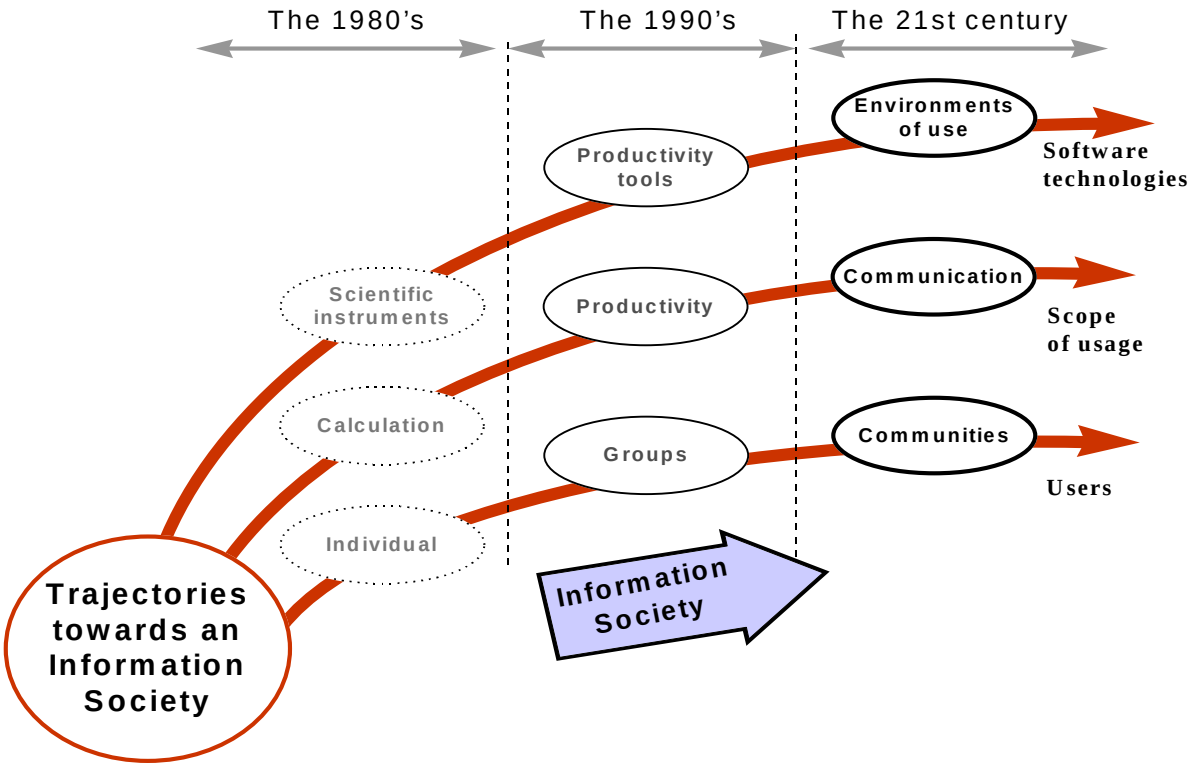

Figure 2: Trajectories towards an Information Society

2.2 High Level (Clusters of) Recommendations

In the light of the schematic of Figure 2, the group arrived at the following high level recommendations[2] (a) promote the development of environments of use, (b) Support communities of users, (c) extend user-centred design to support new virtualities (and novel usage contexts), and (d) establish suitable accompanying measures.

The four topics are interrelated. Thus, recommendations under one topic link with recommendations under a different topic. The type of actions envisaged, with the exception of the accompanying measures cluster, cover all phases of technological development, ranging from feasibility studies, to basic and applied research, and demonstration. Following are brief descriptions of the meaning and rationale for the four high-level recommendations, and the next section elaborates on specific recommended RTD activities.

Promote the development of environments of use. Environments of use imply integrated systems sharable by communities of users. They should, in contrast to the traditional notion of computers as productivity tools, allow for richer communications, and signify the progressive integration of the computing environment with the physical environment (see Figure 3). Moreover, in contrast to tools, which enhance the productivity of individuals, environments of use would promote the concept of loveable systems suitable for a broad range of communication and collaboration intensive activities amongst groups of people. Such

[2] The first three are proposed as RTD topics, whereas the fourth is proposed as a support measure, or "horizontal" activity.

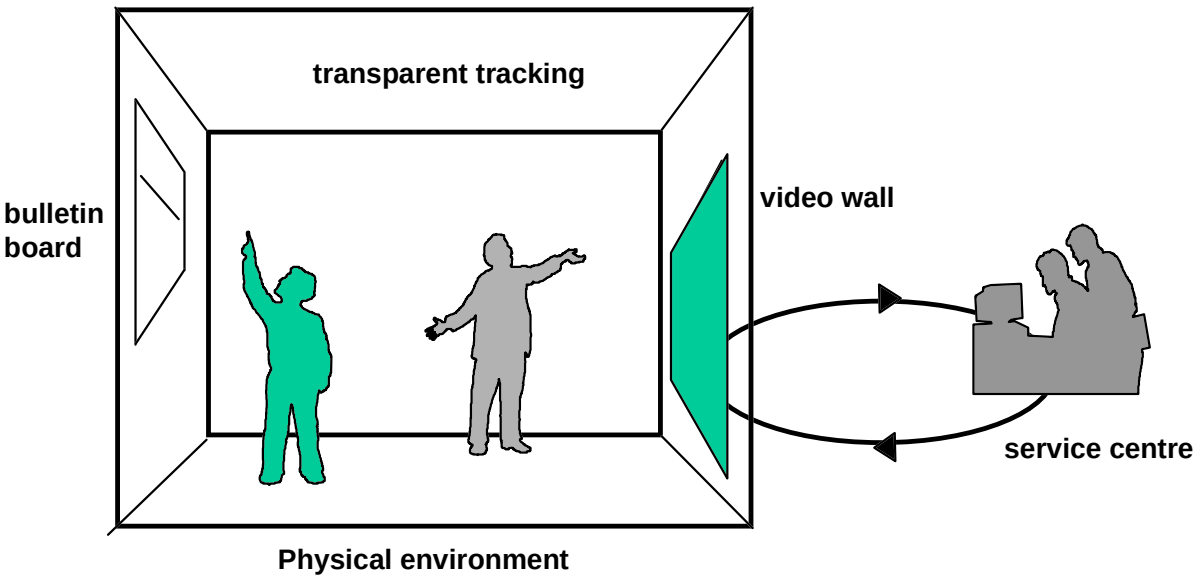

Figure 3: From productivity tools to environments of use

environments should be characterised by sympathy and care for users and non-users3 and should be accessible by anyone, anytime, anywhere. Finally, they should provide unobtrusive means for supporting social activities. As depicted in Figure 3, environments of use are likely to become integral components of daily activities amongst communities of users and facilitate the establishment of new forms of social endeavours. Consequently, they should be conceived and designed as community-centred, sharable, expandable, co-operative, collaborative and responsive media, catering through user and environment monitoring, for a broad range of human needs for both users and non-users. Additionally, they should offer voluntary and context-specific user support, and facilitate error tolerant behaviour and preventive actions against unforeseen circumstances and / or misuse.

Support communities of users. Another critical trajectory en route to an Information Society is the one that progressively shifts the focus of attention from individual users to communities of users. The important element in this trajectory is the emphasis on social interaction in virtual spaces. To design interactions in such virtual worlds, it is pertinent to enhance the currently prevailing interaction paradigms (e.g., Graphical User Interfaces [GUIs] and the World Wide Web [WWW]) to support the broad range of group-centric and communication-intensive computer-mediated human activities (see Figure 4). Such a community-wide design perspective, requires that activities amongst members of communities of users become the primary unit of analysis, as opposed to an individual's keystrokes, or performance measures. Moreover, the design focus should be on the cumulative experiences of the communities of users with the shared resources, as well as on the way in which communities move from early formation to maturity. To this end, there is a compelling need to study and understand how such communities (e.g., the virtual city) are formed, evolve, grow and intra- / inter- operate in order to synthesise methods that facilitate the design of suitable virtualities and computer-mediated activities for all potential community users.

[3] *Nonuser* refers to a member of a community who, although not interacting with the environment himself or herself at a particular point in time, is affected by this environment, or its use by other active users.

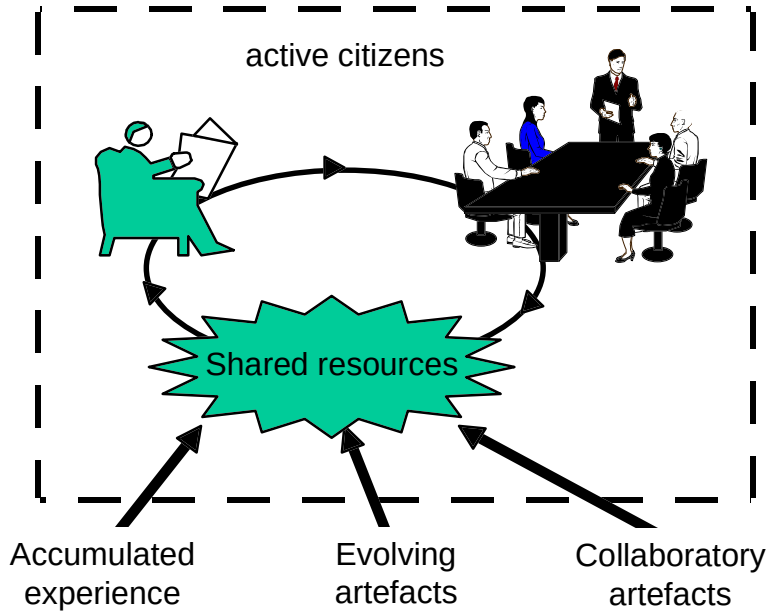

Figure 4: Supporting community-wide experiences

Extend user-centred design to support new virtualities. To facilitate the design of *new virtualities* likely to be encountered in the Information Age, the existing inventory of methods, techniques and tools for user-centred design should be suitably applied and enhanced (see Figure 5). To this end, attention should be drawn upon the accumulated knowledge and results in the social sciences (e.g., human communication theories, language theories, action theories, etc), to promote and facilitate the use of more *developmental* approaches[4] to the study of computer-mediated human activities. In all cases, the tight *evaluation-feedback* loop advocated by user-centred design should provide the primary channel for timely input into design processes, so as to ensure that deficiencies are corrected at an early stage, while updates are less costly to make.

Establish suitable accompanying measures. Support measures cover a whole range of multi-disciplinary and cross-sector actions that are needed to facilitate the development of an industrial environment favourable to an Information Society for the broadest possible end-user population. Actions are needed to promote and facilitate the adoption and diffusion of good practice in the areas of accessibility and usability, so as to ensure quality in the use of products and services. To this end, it is important that accompanying measures are initiated to articulate demand (Kodama, 1992) for universal design, support the industry in adopting novel methods and practices, raise awareness, promote knowledge dissemination and transfer technology in the form of know-how and know-why.

2.3 Specific Recommendations

The high-level recommendations discussed earlier are derived from a collection of specific proposals for future R&D actions that could be implemented in the context of an international

[4] The term *developmental approach* to studying computer-mediated human activities is used to refer to various established theoretical strands within the social sciences and / or psychology which take explicit account of and model development in human behaviour and capability. Such developmental approaches have recently started to progressively find their way into HCI. Examples include *activity theory* (Bødker, 1989; Bødker, 1991; Nardi, 1996), *situated action plans* (Suchman, 1987), *distributed cognition* (Hutchins, 1995), *language / action theory* (Winograd, 1988), etc.

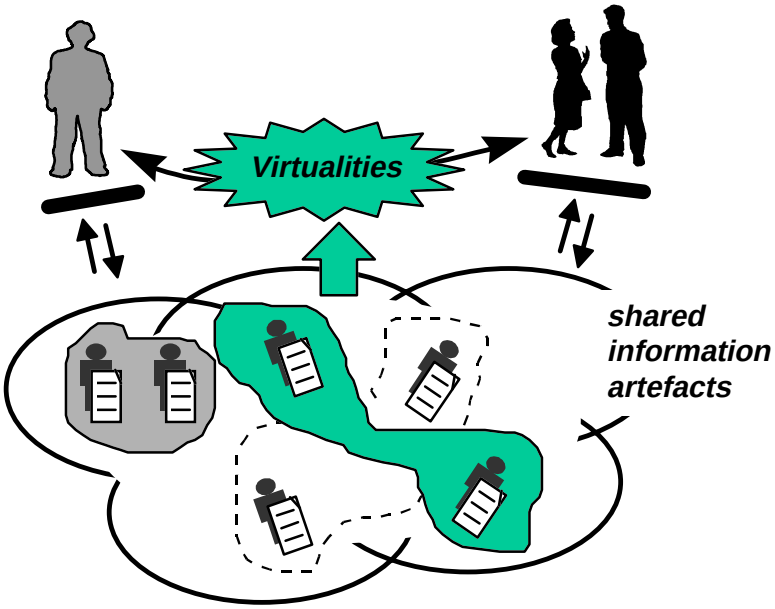

Figure 5: New virtual spaces for individual and collective experience

agenda for collaborative RTD work. A summarising account of the recommendations is depicted in Table 1. In what follows, each of the proposed items is elaborated through: a brief description of the item; identification of key objectives; identification of required types of actions (e.g., basic research, applied research, technological development and demonstration, input to standardisation activity); examples of plausible RTD activities; a summary of some of the expected outcomes. It should be noted that the above structure is not followed for the recommended research actions falling under "Accompanying / support measures", as this thematic topic is a "horizontal" action, rather than an RTD cluster.

3. R&D ROADMAP - SPECIFIC ACTIONS

3.1 Environments of Use

Properties of environments of use. *Environments of use* constitute integrated systems sharable by communities of users (e.g., students, teachers, researchers) and facilitate a broad range of communication, collaboration and social activities. Such environments (e.g., the virtual university, the virtual theatre, the virtual market place) are likely to be substantially different in their architectural underpinnings from conventional interactive software. To facilitate the construction of such environments, studies are needed to identify their respective properties and characteristics, as well as the prevailing norms that characterise their operation.

Actions in this area should aim to (a) identify requirements of different user groups (including people with special needs) and non-users, (b) determine quality attributes such as loveability, usability, accessibility, unobtrusiveness, etc, that characterise environments of use, and (c) map user requirements to technical characteristics.

Table 1: Proposed R&D roadmap

Promote the development of environments of use	***Support communities of users***	***Extend user-centred design to support new virtualities***	***Establish suitable accompanying measures***
Determine desirable properties of environments of use (e.g., augmented capabilities on user's demand, multimodality, cooperativity, intelligence, adaptation, etc)	Individual / collective intelligence and community knowledge management	Develop suitable foundations for design, by applying, integrating and extending existing user-centred design methods to facilitate the design of new virtual spaces	Articulating demand for *design for all*
Novel architectures for interactive systems for managing collective experiences of users and non-users	Methodologies for collecting / analysing requirements and understanding virtual communities	Develop metrics for important quality attributes (e.g., usability, accessibility, adaptation, intelligence, etc)	Supporting the industry
Architectures for multiple metaphor environments	Provide means to access community-wide information resources	Provide computation support for usability engineering (e.g., computer-supported usability platforms)	Awareness and knowledge dissemination
Multi-agent systems and components to support co-operation and collaboration	Develop models to support social interaction amongst members of on-line communities	Extend existing requirements engineering methods to facilitate the elicitation of requirements in novel contexts of use and different user groups.	Technology transfer
Support individualisation and user interface adaptation (e.g., adaptability and adaptivity) of environments of use		Promote user involvement and develop protocols for effective user participation in design activities	
		Investigate and provide design recommendations for alternative interaction modalities and their combinations	

The type of actions envisaged include basic research, applied research and demonstration. Typical RTD activities may include, but are not limited to, the following:

- Undertaking of experimental studies to determine requirements of, and suitable interaction mechanisms amongst, members of on-line communities;
- Identification and assessment of desirable properties of environments of use (e.g., accessibility, usability, co-operativity, adaptability, individualisation, capability to provide augmented services on user's demand, intelligence);
- Development of demonstrators of innovative, integrated, sharable and inter-operable systems for on-line communities of users facilitating social interaction and exchanges amongst members.

Expected outcomes may include empirical evidence, requirements, guidelines, demonstrator prototypes.

Novel architectures for interactive systems for managing collective experiences of users and non-users. Traditional interactive software architectures do not account for several of the desirable or envisioned properties of environments of use, such as interoperability, adaptation, co-operation, intelligence, etc (Stephanidis et al., 1998). Actions are needed to refine / extend / revise existing, as well as introduce new architectural models that can address the new requirements of such types of systems and facilitate the broad range of computer-mediated human activities which will emerge.

Actions in this area should strive to introduce and validate new architectural models for interactive software; define desirable architectural properties (e.g., adaptation, co-operation, collaboration, portability, interoperability, scaleability, modifiability) and produce guidelines on how they can be met (e.g., for adaptation, these would include the issues of platform abstraction, integration, augmentation, etc). These actions should span basic and applied research, technological feasibility studies, as well as technology demonstration. Examples of RTD activities include, but are not limited to:

- Exploration of novel architectural models for interactive software (covering both interactive and non-interactive elements).
- Illustration of technical feasibility of new architectural models.
- Development of systems complying to the proposed architectural models.
- Evaluation and usability assessment of demonstrators.
- Provision of guidelines for integrating the proposed architectural models into new systems and services.

The expected outcomes may include new architectures, feasibility studies, prototypical demonstrators, guidelines and tools.

Architectures for multiple metaphor environments. The notion of a multiple metaphor environment implies a particular computer-based embodiment of an integrated system, capable of performing context-sensitive mapping between concepts from a source domain to symbols in a (target) presentation domain (or metaphor), and vice-versa. Alternatively, it may be conceived as an integrated platform of multiple and concurrently available interaction toolkits, capable of context-sensitive mapping. The fusion of multiple metaphors into an integrated system will allow such systems to adapt to different user requirements and contexts of use. Actions are

needed to determine how multiple metaphor environments can be constructed and how they can provide the technology for building systems exhibiting desired usage properties.

Actions in this area should aim to: (i) explore alternative metaphors for interaction; (ii) develop interactive computer-embodiments of metaphors; (iii) determine properties of multiple metaphor environments (e.g., adaptive change, user awareness, context sensitive processing, intelligence); (iv) provide experimental evidence and illustrate face validity of proposals; (v) develop demonstrators of multiple metaphor environments; and (vi) compile recommendations and guidelines for building and supporting multiple metaphor environments. These actions could take the form of basic and applied research and should accommodate a strong element of technological demonstration. Examples of RTD actions may include, but are not limited to:

- Investigation of alternative theories of metaphor[5] and analysis of how they could influence the construction of environments of use.
- Exploration of novel metaphors suitable for new virtual spaces.
- Development of systems that exhibit characteristic properties of multiple metaphor environments and tools for developing multiple metaphor environments.
- Undertaking of evaluation and usability assessment of demonstrators.
- Provision of guidelines for developing new metaphors and building multiple metaphor environments.
- Establishment of quality criteria for multiple metaphor environments.

Expected outcomes include, but are not limited to novel interaction metaphors, methodologies for developing interaction metaphors, architectural abstractions for multiple metaphor environments, demonstrators, experimental evidence, design and development guidelines and tools.

Multi-agent systems and components to support co-operation and collaboration. Two of the important dimensions of environments of use are expected to be (a) a further shift in the computing paradigm, departing from the desktop embodiment of the computer to distributed "intelligence" in the living environment; this, in turn, will necessitate a departure from the traditional direct manipulation approach in using a computer environment, to more delegation-oriented activities, and (b) co-operation and collaboration, which will need to be further facilitated and actively supported, so that humans will be able to seamlessly perform joint activities, independent from geographic location, specific characteristics of the software and hardware used, differences in language and culture, etc. In this context, and in order to address the two dimensions together, it is necessary to cater for environments that will be jointly inhabited by human and software agents, and that will interact and co-operate with each other, towards common goals and under a multitude of social and other circumstances.

Actions in this area should strive to support and facilitate the co-operation and collaboration between humans in the new environments of use. Of particular interest is the construction of systems and components that will facilitate the coexistence of humans and software entities, in diverse contexts of use, allowing them to communicate, to effortlessly share knowledge and activities, and to evolve. The type of actions envisaged include basic research, applied research and demonstration efforts. Examples of illustrative RTD activities include, but are not limited to:

[5] For a review of metaphor theories, see Lakoff and Johnson (1980).

- Investigation of suitable agent architectures and frameworks for constructing computational environments that exhibit voluntary domain-specific support and guidance, as well as interoperability with other tools and systems.
- Development of agent-based communication languages with embedded constructs facilitating social interaction (e.g., multiple ontology references, ability to employ different “social” contracts, communication across heterogeneous media / platforms).
- Experimentation with co-operative intelligent agents, personal assistants and service integration agents.
- Development of communities of agents (e.g., formation of virtual communities of agents based on thematic interests).
- Construction of multi-agent environments (e.g., support for different architectures and different languages).

The expected results include, but should not be limited to, architectural models, languages for agent-based communications, technology demonstrators and guidelines.

Individualisation and user interface adaptation. A critical property of environments of use will be their capability for adaptation and individualisation. This is necessary to ensure accessibility by *all* users to community-wide information and communication resources, as well as to satisfy experiences in the use of systems that carry out a broad range of social activities. In this context, adaptation refers both to the system's capability to tailor aspects of its interactive behaviour prior to an interactive session in anticipation of a user's requirements (adaptability), as well as to run-time dialogue enhancements on the basis of dynamically acquired and maintained knowledge regarding the user. Individualisation is a term that is typically associated with adaptation (adaptivity). In the present context, it implies additional capabilities on the part of the system - which need not be covered by adaptation - such as transparency and modifiability of a system's knowledge about the user, as well as the broad range of issues pertaining to ethics, privacy and security.

Actions in this area should aim to: (i) provide methods to facilitate the design of adaptations; (ii) construct tools to support adaptable and adaptive behaviour; (iii) evaluate and assess adaptation strategies; (iv) develop instruments for evaluating adaptable and adaptive behaviour; (v) explore alternative architectural models for user interface adaptations; and (vi) assess user's opinion towards individualised interactions. The type of actions envisaged include basic research, applied research, development and demonstration efforts. Examples of RTD activities include, but are not limited to:

- Enrichment of the currently prevalent concept of adaptation to accommodate changes in the overall community-based environment (e.g., introducing new members and new services, revised social norms).
- Determination of suitable strategies to facilitate novel adaptation objectives, such as customisation through the combination of interactive pluggable modules, interpreting the intentions of user operations, etc.
- Investigation of the acceptability of adaptations and the social implications for individuals and communities of users.
- Demonstration of economic, social and personal value of adaptable and adaptive systems.
- Development of prototypical demonstrators of adaptable and adaptive systems.

- Assessment and exploration of alternative technological options towards improved adaptable and adaptive behaviour.

Some of the expected outcomes include, but are not limited to, demonstrators of adaptable and adaptive environments of use, enriched theoretical models of adaptation rooted in social sciences and substantiated into suitable interactive environments, guidelines for developing adaptable and adaptive systems.

3.2 Supporting Communities of Users

Individual / collective intelligence and community knowledge management. Recent advances in telecommunications and, in particular, networking, have broadened the scope and type of computer-mediated human activities. Increasingly, users find themselves associated with various virtual / on-line communities to attain professional and social goals. Knowledge, therefore, no longer constitutes an individual's asset, but a community-wide resource which can be shared and articulated by members of that community. Actions are needed to support the life-cycle of communities and community-based knowledge management.

Actions in this area should strive to: facilitate capturing community-generated wisdom and collective experiences; support social awareness, collaboration, knowledge sharing and persistence, and the exchange of experiences. The type of actions envisaged include basic research, applied research and technology demonstration. Examples of RTD activities include, but are not limited to:

- Development of tools for managing large information spaces (e.g., knowledge ontologies, evolutionary knowledge repositories, recommender systems).
- Development of interaction mechanisms to cope with new virtual spaces (e.g., collaborative filtering, virtual and augmented realities, etc).
- Development of agent-based communication languages for knowledge sharing.

Expected outcomes may include demonstrator prototypes, tools for building collaborative systems, inter-operable environments, or any other component that fits the above.

Methodologies for collecting / analysing requirements and understanding virtual communities. Traditional models and tools of information processing psychology, focusing on individual users, need to be enhanced to provide a broader view of HCI, accounting for small groups and communities of users. Novel methodologies making use of analytical and developmental approaches to human communication need to be developed to provide prescriptive frameworks for the study of communities of users and to support the broad range of computer-mediated human activities. Suitable models should facilitate effective protocols for collecting / analysing requirements and understanding on-line virtual communities.

Actions in this area should aim to: (i) develop an understanding of virtual community life-cycles; and (ii) investigate how on-line communities are formed, operate and grow. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Exploration of alternative models from the social sciences for the study of virtual communities.
- Development of novel methods for capturing requirements of virtual communities.

- Development of novel design methods and tools for mapping requirements to technical specifications.
- Experimentation with virtual communities.

The expected outcomes include, but should not be limited to methodologies for eliciting / analysing requirements and studying virtual communities of users, guidelines for setting up virtual communities, as well as experimental demonstrators.

Accessing community-wide information resources. Information generated and captured by virtual communities of users should be stored and accessed in a manner that is effective, efficient and satisfactory for the individual members of the community. As this information is likely to expand rapidly and have a long life-cycle (extending beyond a particular generation of users) it needs to be accessible through different media and from a variety of devices and locations. Actions are needed to facilitate human interactions with large information spaces (and concurrently with other humans) and to provide technological solutions which will make community-wide information resources accessible, scaleable to new generations of technology, persistent and secure. For example, the WWW provides enormous potential to enrich people's lives in many spheres, but understanding how to exploit the potential of the Web, requires, at present, considerable skills and experience. Current WWW tools and access methods are general purpose, like an "operating system" interface. New methods and techniques are required to support a much wider range of users and to facilitate access to resources related to specific tasks in areas including education, training, leisure, contacting people with common interests, supporting local communities, etc. This needs to be integrated with existing consumer devices, such as cable TV and telephone, without necessarily demanding the skills needed to operate a Personal Computer.

Actions in this area should aim to (a) ensure accessibility and usability of community-based information resources by *all* potential users, (b) develop suitable interaction techniques that meet the requirements of individual members of communities of users, and (c) establish demonstrators of good practice. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- ➪ Investigation of and studies on user requirements for novel interaction technologies.
- ➪ Development of advanced 3D domain-specific visualisations.
- ➪ Analysis and experimentation with new metaphors for interaction in social settings.
- ➪ Development of multimodal interaction mechanisms (e.g., gestures, natural language understanding, tactile, and their combination).
- ➪ Exploration of alternative designs for non-visual modalities to facilitate interaction in radically different contexts of use.
- ➪ Development of novel interaction techniques based on emerging technologies (e.g., wearable computing, virtual / augmented realities).
- ➪ Development of advanced content-based retrieval engines.
- ➪ Development of technologies for managing large information spaces (e.g., Digital Libraries).

The expected outcomes include, but should not be limited to, prototypical demonstrators, empirical studies, new implemented interactive metaphor environments, tools for building multimodal, or alternative-modality interactions, guidelines for human interfaces, inter-

operable interactive components, tools to present and support navigation and searching in large information spaces.

Social interaction amongst members of on-line communities. A primary characteristic of the emerging broad range of computer-mediated human activities in the Information Age is their inherently group-centric and social nature. In order to facilitate the development of "sociable" interactive environments, it is important to enrich the currently prevailing practice with concepts which have a social focus. New models are needed to facilitate social awareness, social immersion and social navigation in large virtual spaces. Moreover, such models should be validated in real contexts of use to determine their suitability as prescriptive instruments for new design foundations.

Actions in this area should aim to explore novel concepts for embodying information spaces (e.g., the virtual theatre, the virtual city, the virtual market place) and assess their relevance to the design of virtual communities; provide experimental evidence to support novel design concepts for community-based activities (e.g., collaborative concept creation, community-based learning). The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Construction and validation of conceptual / prescriptive frameworks for envisioning virtual communities.
- Development and validation of novel community-based navigation concepts.
- Investigation of methods for evolutionary and persistent knowledge management in virtual communities.
- Development and validation of guidelines for constructing virtual communities.
- Development of demonstrators of "sociable" interactive environments for virtual communities.
- Development of tools for interpersonal communication between humans within and across the same virtual communities.

The expected outcomes include, but should not be limited to, theoretical and conceptual models, experimental foundations, guidelines, technical and prototypical demonstrators.

3.3 Extend User-Centred design to support the construction of new virtualities

Foundations for designing computer-mediated human activities in the Information Age. User-centred design (Norman and Draper, 1986) has surfaced as the primary design approach to facilitate usable interactive systems. It offers a broad collection of tools and methods for planning, iterative development and evaluation, while it fosters a tight evaluation feedback loop to assure that deficiencies are identified and corrected at an early stage of the development life-cycle, when the cost of refinement is not prohibitive. In view of the trends in technology, it becomes evident that in order to provide the required support for the design of the broad range of computer-mediated human activities in the emerging virtual spaces, user-centred design, as a philosophy, should be extended to provide a more prescriptive design framework. To this end, actions are needed to apply, refine and extend existing techniques and tools of user-centred design with concepts from the social sciences, so as to provide a broader foundation for HCI design.

Actions in this area should strive to assess potential HCI design contributions rooted in disciplines that focus on human communication in social contexts (e.g., developmental psychology, the social sciences, the humanities, etc); extend existing analytical design approaches (e.g., design space analysis techniques) with social constructs to provide new methods for studying virtual spaces. The type of actions envisaged include basic research, applied research and technology demonstration. Examples of RTD activities include, but are not limited to:

- Exploration and assessment of emerging, alternative approaches to HCI design based on activity theory (Bødker, 1989; Bødker, 1991), language / action theories (Winograd, 1988), situated action models (Suchman, 1987), distributed cognition (Hutchins, 1995), and other frameworks from the social sciences (e.g., structure-functionalistic theory);
- Development of new tools for studying social, group and individual behaviour and informing design practice (e.g., taxonomies of requirements, capabilities and design alternatives);
- Compilation and validation of measurable yardsticks (e.g., metrics) for evaluating new virtualities and assessing social impact;
- Development of prototypical implementations of concepts (e.g., the virtual city) using novel design techniques and approaches and compilation of guidelines and examples of good practice.

The expected results include, but should not be limited to novel design methods and tools, guidelines, experimental and empirical evidence, as well as technology demonstrators.

Metrics for important interaction quality attributes. Metrics provide a powerful instrument for measuring different aspects of an interactive system. In the past, the field of HCI has attempted to provide metric-based techniques in the form of usability scales for measuring qualities of interactive systems. Examples include usability scales based on performance criteria (e.g., effectiveness, efficiency and satisfaction), cognitive workload, etc. These techniques usually take the form of a questionnaire (e.g., for measuring user satisfaction and cognitive workload), or user tests (e.g., in the case of measuring effectiveness and efficiency). Despite the fact that such techniques have been around for several years, their adoption has been rather slow. Consequently, actions are needed to (a) extend the available range of metrics to cover additional quality attributes such as accessibility, adaptation, intelligence, etc, likely to determine the outcome of computer-mediated human activities in the emerging Information Age, (b) embed such metrics into tools for automatic evaluation and measurement, and (c) establish (technology-independent) protocols for measuring quality attributes of systems, taking account of the various contexts of use and the new virtualities that such systems are intended to support. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Development of metric-based instruments for quality attributes, or design targets, including accessibility, co-operativity, social awareness, social immersion, intelligence, adaptability, adaptivity, etc.
- Development of life-cycle metrics which allow usability, accessibility and quality in use to be included in the requirements specification, and to be monitored during early development activities, in order to provide confidence that final validation of the designated quality attributes of the finished system will meet the specified requirements.

- Studies intended to correlate product attributes for usability and accessibility with quality in use to address a range of questions such as: which usability and accessibility features need to be designed into a product so that it provides quality in use for specific user groups and tasks? how can these be specified and evaluated without the expense of laboratory usability testing? what is the correlation between the inclusion of specific features and the user perceived quality of the final system for particular user groups?
- Demonstration of the validity of the above techniques by applying them across design cases, contexts of use and application domains.
- Development of tools for automatic evaluation and measurement of software quality based on metrics.
- Provision of guidance as to how different quality attributes may be attained.
- Formulation and validation of guidelines on the basis of experimental evidence.

The expected results include, but should not be limited to new instruments, tools for community-centred design, examples of good practice, experimental evidence.

Computational tools for usability engineering. Usability engineering has been traditionally conducted by experts without the assistance of computational environments or tools. This bears on cost factors and rates of adoption of specific techniques. Computational environments to support usability engineering have the potential to lead to both cost-justification and improved usability practices, as they may automate certain tasks, guide designers towards usability targets or provide extensible environments for capturing, consolidating and reusing previous experience. Actions in this area should try to provide inter-operable components covering the broad range of usability engineering tasks within a user-centred design protocol. The intention could range from attempts to fully automate specific and well defined stages, to augmenting the capabilities of human designers or usability practitioners to undertake and carry out effectively a collection of tasks.

Actions in this area should aim to investigate characteristic properties of, and to provide for computer-supported usability engineering platforms comprising inter-operable software components. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Development of tools for a range of design and evaluation tasks; for example, working with guidelines, facilitating inspections, critiquing tentative designs, capturing / reusing past experience, evaluating designs, capturing design rationale, embedding rationale into designs, providing computational support for metric-based techniques, generating specifications which meet predetermined usability targets, cost-benefit analysis, etc.
- Development of usability support environments to integrate existing usability / accessibility tools and new tools for *design for all*; such platforms should allow for the accumulation of results from usability and accessibility assessment activities, impact analysis, and cost / benefit analysis; moreover, they should offer support for the resultant modification-implementation decisions.
- Development of planning tools to assist with selecting the best methods and techniques for user-centred design, usability and accessibility, and integrating them into existing development activities; the tools should include information on advantages, disadvantages and cost benefits of each instrument or method, and the skills required.

- Development of inter-operable architectures linking usability platforms to design environments and user interface development systems.
- Development of requirements elicitation tools on widely available platforms (e.g., WWW).
- Development of responsive prototyping media tools addressing alternative and combination of modalities.

Expected outcomes include, but should not be limited to, computer-based usability platforms, improved methodologies for user-centred design and usability engineering.

Requirements engineering methods to facilitate the elicitation of requirements in novel contexts of use and different user groups. The study of requirements in the design of computer-based interactive systems has always been a challenge for system designers and developers. With the advent of user-centred design, several tools have emerged to facilitate requirements elicitation, capture and / or specification. However, existing techniques (e.g., brainstorming, scenarios, prototyping) have only been used in traditional contexts of use to elicit requirements of average / typical users. It is, therefore, important that existing techniques are refined and extended to facilitate requirements engineering in novel contexts of use and for user groups with radically different requirements.

Actions in this area should strive to provide improved means for eliciting, capturing and consolidating requirements for a broad range of computer-mediated human activities in the Information Age, including the development of tools to facilitate the mapping of requirements to design concepts. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Development of software environments for Requirements Engineering.
- Development of tools for collecting / documenting requirements in novel contexts of use.
- Development of tools for collecting / documenting requirements of different user groups, including people with special needs.
- Development of software tools for integrating requirements engineering into iterative prototyping environments.
- Development of taxonomies of human abilities versus interaction requirements.

The expected outcomes include, but should not be limited to, improved requirements for engineering instruments (e.g., questionnaires, protocols), and tools to facilitate the transition from requirements specification to iterative prototyping.

Protocols for effective user participation in design activities. User involvement in the design of computer-based interactive systems has long been a challenging issue. Despite its potential value, it needs to be carefully planned and assessed in different phases of a product's life-cycle. Participatory design has provided useful insights into how user involvement may be managed in practice and offers several tools and guiding principles. However, the existing wisdom offers very little in the direction of involving different user groups with diverse abilities, skills, requirements and preferences. Therefore, actions should be undertaken to refine and extend the available instruments in such a way that they can effectively guide the design of new computer-mediated human activities.

Actions in this area should aim to: (i) establish new methods and tools for managing user participation in design projects which are intended to be accessible to the broadest possible end-user population, including people with special needs; and (ii) promote practice and experience of participatory design and develop suitable models. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities include, but are not limited to:

- Development of conceptual models and guidance for participatory design in suitable selected application domains and design cases (e.g., accessibility).
- Assessment of the cost and benefits of participatory design in real world case studies.
- Provision of guidance in the use of different techniques for participatory design.
- Establishment of links between participatory design and user-centred design activities.

The expected outcomes include, but should not be limited to, novel methods for participatory design, cost / benefit studies, practice and experience, guidelines.

Design recommendations for suitable / plausible interaction modalities and combinations. In the recent history of HCI, the visual modality has been predominant in the systems and tools which have been developed for humans to work with[6]. However, with the advent of multimedia and the new capabilities that are being offered, it becomes pertinent to enrich, rather than replace, the visual modality to facilitate "broad-band" interactions between humans and artefacts. Such media-rich environments are increasingly needed due to the variety in the context of use which may render certain presentations inappropriate. Thus, it is important to investigate how to design for alternative modalities and how to combine modalities into integrated environments. This would not only facilitate more effective computer-mediated communication, but it would also substantially reduce the problems faced by users with special needs. This line aims to promote R&D activities that would facilitate the creation of a design corpus for constructing purely multimedia interactions, as well as the development of the required tools which would ease the task of constructing and building such interactions.

Actions in this area should aim to establish a basis for designing for alternate interaction modalities and combinations of modalities, as well as to demonstrate the benefits of developing multimodal and multimedia systems for communities, groups and individual users. The type of actions envisaged include basic research, applied research, and technological development and demonstration. Examples of RTD activities, include but are not limited to:

- Experimental studies on design for alternative modalities.
- Development and validation of a taxonomy of modality combinations in computer-based interactive software (detailing issues, such as modality compatibility, modality expressiveness, redundancy) to guide towards effective multimodal interaction design.
- Assessment of the usefulness of multimedia in specific application domains and contexts of use.
- Experimentation with alternative interaction design (e.g., non-visual).
- Demonstrators of advanced multimodal interaction techniques (e.g., gestures, speech recognition, tactile interaction).

[6] Amongst the very few exceptions is interpersonal communication, which makes use of the auditory modality.

Expected outcomes include, but should not be limited to, experimental evidence, guidelines for designing for alternative modalities and modality combinations, novel interaction techniques and technology demonstrators.

3.4 Establish Suitable Accompanying Measures

Articulating demand for design for all. In the short-term, support efforts should be devoted to the articulation of demand for *design for all*. Articulating demand has been defined as a two-step process: first, translate market data into a product concept; and second, decompose the concept into a set of development projects. It should be mentioned that such a (two-step) process is sufficient only in cases where a market already exists, and has reached a level of maturity, whereby it can react and respond to the needs of its customer base. However, in the case of the emerging Information Society, it is argued that there is an additional short-term need for creating awareness as to the new opportunities offered, as well as to the new challenges likely to emerge.

Consequently, support measures are needed in the direction of raising consumer awareness on the value of accessibility and usability, educating consumers and producers in the need to include requirements for usability and accessibility in product specifications, as well as helping them evaluate usability and accessibility when making design, or purchase, decisions. Such actions would help towards building a public expectation for accessible and usable products and services, and intolerance of inaccessible forms of technology. Additionally, until a certain maturity level is reached and more effective end-user input into the design process can be attained, procurement guidance is necessary with regards to accessible and usable technology.

Regarding subsequent steps required for demand articulation, namely the translation of market data to product concepts and the decomposition of product concepts to development projects, it is important that a range of questions are addressed. These include: (i) what product types are needed in the market; (ii) how they could be produced; (iii) through which technologies; and (iv) what other characteristics should the envisaged technologies exhibit. The type of actions that area expected in this area are accompanying / support measures (or horizontal actions).

Supporting the industry. This line of action should be targeted towards the creation of an environment favourable to industrial innovation. At the core of such activities should be the provision of incentives towards *design for all*. Industrial incentives need not necessarily be of a financial type, though this would be critical for Small and Medium size Enterprises (SMEs). They should also include access to research results that would be difficult to obtain otherwise, provision of a suitable infrastructure, collaborative R&D activities for technology transfer (see also later section on "Technology Transfer"), as well as other policy initiatives, such as the establishment of an Accessibility / Usability certificate.

There is also a compelling requirement for speeding-up current standardisation processes, as well as for more intensive international co-ordination of standards in the long-term. To this end, actions are needed to facilitate co-ordination across efforts initiated in the context of research consortia (e.g., the W3C - WAI[7] project and the ERCIM Working Group on "User Interfaces for All"[8]), as well as in national (e.g., HFES / ANSI[9]) and international

[7] World Wide Web Consortium - Web Accessibility Initiative (1997). For more information please refer to http://www.w3.org/WAI/

[8] For more information please refer to http://www.ics.forth.gr/proj/at-hci/UI4ALL/index.html

[9] See also (HFES/ANSI, 1997)

standardisation bodies (e.g., the new work item on accessibility by ISO 9241 / TC 159 / SC 4 / WG 5). Co-ordination in this context should also involve exchange of input so as to avoid incompatible standards. To this effect, the requirements of mainstream industries need to be carefully studied so as not to impede adoption of *design for all* principles and recommendations. Another important issue in this line of action is the establishment of suitable assessment and certification measures for accessibility and usability of new products and services.

Legislation is also needed to provide the framework of operation, and the required incentives for both the consumer base and the industry. To this effect, recent experience in the USA with the Americans with Disabilities Act of 1993 and the Telecommunications Act of 1996 should be assessed, and similar actions should be encouraged internationally. Such efforts could also draw upon general rules and recommendations compiled by industrial consortia (e.g., The Telecommunications Policy Roundtable in USA), technical committees (e.g., the Association of Computing Machinery (ACM) Public Policy Committee) and international organisations (e.g., the United Nations General Assembly Standard Rules of 1995). The type of actions that are expected in this area are accompanying / support measures (or horizontal actions).

Awareness and knowledge dissemination. One of the critical impediments to the adoption of universal design practice is the lack of qualified practitioners who understand what the requirements for universal access and quality in use are. To overcome this, it is recommended that, in the short-term, accessibility, usability and quality in use are introduced as mandatory components of university education.

Additionally, efforts should be devoted to the collation and dissemination of comprehensive information on the practical resources available for user-centred design, usability and accessibility. This would include information on the available methods, techniques and tools for user-centred design, usability and accessibility, the skills required to adopt, internalise and appropriate the benefits of the methods, as well as their socio-economic benefits and costs. Such efforts would necessarily build upon the accumulated wisdom[10] collected through past and on-going collaborative project work in the context of trans-national projects.

Dissemination methods could include guidance and reference documents, lists of resources and provision of tutorials and workshops for potential consortium partners. Ideally, such activities could be supported through the sponsorship of a network of excellence which would adopt the above targets as part of its global function. Such a network could employ specific means to desired ends. For instance, the dissemination targets could be promoted by organising and running on pre-determined time intervals a multi-disciplinary conference with the intention to bring together the previously disparate communities, and to help them develop a shared

[10] The European Commission has funded several projects aiming to collect, consolidate and disseminate available knowledge and experience. Examples include: INUSE ("European Usability Support Centres", Telematics Applications Programme, Telematics Engineering Sector, 1996-1998); RESPECT ("Requirements Engineering and Specification in Telematics", Telematics Applications Programme, Telematics Engineering Sector, 1996-1998); MEGATAQ ("Methods and Guidelines for the Assessment of Telematics Application Quality", Telematics Applications Programme, Telematics Engineering Sector, 1996-1998); BASELINE ("Data for User Validation in Information Engineering", Telematics Applications Programme, Telematics Engineering Sector, 1996-1998) INCLUDE ("INCLUsion of Disabled and Elderly people in telematics", Telematics Applications Programme, Telematics Engineering Sector, 1996-1998); ACCESS ("Development Platform for Unified Access to Enabling Environments", Technology for the Disabled and Elderly (TIDE) Programme - Bridge Phase, 1994-1996), USER ("User Requirements Elaboration in Rehabilitation and Assistive Technology", Technology for the Disabled and Elderly (TIDE) Programme - Bridge Phase, 1994-1996).

understanding of the common problems and goals. This will progressively encourage the adoption of universal design principles by professional bodies and individuals in the medium- to long-term. The type of actions that are expected in this area are accompanying / support measures (or horizontal actions).

Technology transfer. Effective and efficient technology transfer is another critical target, requiring a range of support measures to be effected. Technology, in this context, includes both embodied and disembodied forms (Vernardakis, Stephanidis and Akoumianakis, 1997a). Embodied technology is evident in new products and services, machines, tools and research equipment. Disembodied technology appears as learning-by-doing, documentation, know-how and know-why. To facilitate successful transfers of technology, suitable mechanisms are needed in the short-term, to the effect of targeted and purposeful exchange of knowledge, know-how and know-why. It is recommended that, from the broad range of technology transfer mechanisms which can be considered, emphasis is on advanced measures (such as co-operative R&D, joint venture R&D agreements, joint ventures aimed at keeping partners informed, large / small firm agreements), rather than simpler ones (such as licensing, technical advice, technical support, contract of R&D). This is because the latter cluster is better suited for the type of transfers (e.g., know-how and know-why) that is required. In this context, it is important to mention that collaborative, inter-disciplinary, multi-national, multi-cultural and cross-industry R&D activities, involving industry and research institutions, are of primary importance.

Moreover, given the broad range of technologies that will drive the emergence of the Information Society, it is recommended that any contemplated technology transfer effort should closely and carefully consider potential sources and recipients and assess alternative technological performance thresholds (Vernardakis, Stephanidis and Akoumianakis, 1997b). In principle, it is recommended that *design for all* should be the aim of all emerging technologies. The newer a technology, the greater the chances are of being influenced in the direction of facilitating *design for all*. However, for such a condition to materialise, a "monitoring system" for critical emerging technologies should be established; this could be part of an extensive collaborative network, and should aim to identify potential synergies and possibilities for international collaborative R&D efforts. The type of actions that are expected in this area are accompanying / support measures (or horizontal actions).

4. SUMMARY AND CONCLUSIONS

The emergence of the Information Society creates new opportunities and challenges for *all* citizens. The progressive shift from physical goods to information-based products and services is likely to introduce new patterns for demand and supply of such products and services. One important issue in this transition is the extent to which the emerging Information Society advances in a manner which ensures non-discrimination and social and economic inclusion of the broadest possible end-user population, thus posing the requirement for a society caring for *all* citizens.

This article presents an R&D roadmap for activities that could be undertaken in the context of international collaboration in research and technological development, to contribute towards the advancement of an Information Society accessible to the broadest possible end-user population.

To this effect, this document discusses research items under four main thematic topics, namely, *promote the development of environments of use*, *support communities of users*, *extend user-*

centred design to support new virtualities, and *establish suitable accompanying measures and supporting actions*. Though all four of them have a cross-sector nature, the first three are RTD clusters, whereas the fourth is intended as a (horizontal) support action. Each thematic topic has been elaborated in terms of a contextual description and a cluster of specific recommendations for collaborative R&D activities. The description of the topic provides an insight as to how this topic emerged and the rationale for including it as a main research target. The specific recommendations that relate to each topic exemplify the context and scope of the proposed R&D activities.

The four topics are interrelated. Thus, recommendations under one topic link with recommendations under a different topic. For example, the recommendation for suitable methods and tools to support the design of new virtualities relates to the recommendation for novel architectures for adaptable, adaptive, multimodal and co-operative interactive systems. It is important to note that such interrelations do not imply any particular preference, or priority. Instead, they indicate possible pathways for the diffusion of innovative action across, or within sectorial programmes of national, European and trans-national non-market institutions, such as for example the European Commission of the European Union and the National Science Foundation in the USA. This means that some of the recommendations may be considered in the context of specific Key Sectorial Actions, or as components of a cross-sector theme that spans across Key Actions and domains.

Finally, it should be mentioned that the International Scientific Forum "Towards an Information Society for All" is in the process of becoming an International Association aiming to promote the evolving objective of an Information Society accessible and acceptable to *all* citizens, through a series of activities. Some of these activities will aim to strengthen trans-national co-operation at various levels, as well as to establish an international conference and an archival scientific journal. The next ISF meeting[11] is scheduled to take place in Munich, Germany, August 22-23, 1999, in the context of the 8th International Conference on Human Computer Interaction (HCI International '99).

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[11] The specific objectives of the third ISF meeting are three-fold. First, the workshop will aim to review recent advances in HCI and other related fields and assess their impact in the context of selected emerging Information Society Technologies (e.g., Healthcare, Disabled and Elderly, Transport, Digital Libraries) and novel application domains (e.g., Electronic Commerce). Secondly, the workshop will aim to consolidate the group's exchanges into meaningful recommendations for future collaborative activities in the involved fields (e.g., guidelines for new HCI paradigms in the context of the emerging Information Society). Finally, the workshop will devise a suitable dissemination mechanism and plan for reaching a wider range of target audience including industry, non-market institutions, research and academic community, user organisations, standardisation organisations, etc. These objectives are expected to advance the notion of user acceptability in Information Society Technologies beyond the traditional fields of inquiry (e.g., HCI, Assistive Technologies, housing, consumer electronics) and into the core of emerging Information Society Technologies and application domains.

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