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Foreword

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

Introduction

Motivated by the trend towards regulatory requirements, the European ICT industry is preparing for developing solutions for making their products usable for all users, including elderly users and those with disabilities.

Where a "Design for All" solution is not readily achievable, one-solution that may be chosen is to offer technical interfaces to permit the use of so called assistive devices that fill the gap between the user interface of the device and the abilities of the user. Elderly and disabled users would benefit from standards for these interfaces so that one assistive device, e.g. a display for the presentation of information in large letters, can be used for the widest possible range of products from different manufacturers. The manufacturers themselves would benefit by complying with European and international regulations if they offer a compatible interface even if they leave the production of the assistive devices to third party manufacturers.

1 Scope

The present document gives guidance on the needs of older and disabled people for assistive technology devices and the requirements for the interconnection of such devices to Information and Communications Technologies (ICT) systems. The report considers devices for user interface input (e.g. keyboards) and output (e.g. display content) as well as speech and video transmission. It reviews available transmission technologies (e.g. Bluetooth and DECT) and requirements for transmission protocols.

The present document is applicable to assistive technology devices and information and communication devices which have an interface for communicating with a user.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] CEN/CENELEC Guide 6: "Guidelines for standards developers to address the needs of older persons and persons with disabilities".

[2] ETSI EN 300 175-1 (V1.4.2): "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 1: Overview".

[3] ETSI ETS 300 388 (Edition 1): "Integrated Services Digital Network (ISDN); File Transfer, Access and Management (FTAM) over ISDN based on simple file transfer profile".

[4] ETSI ETS 300 679 (Edition 1): "Terminal Equipment (TE); Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids".

[5] ETSI I-ETS 300 245-1 (Edition 2): "Integrated Services Digital Network (ISDN); Technical characteristics of telephony terminals; Part 1: General".

[6] ETSI EG 202 116: "Human Factors guidelines for ICT products and services; Design for All".

[7] ETSI TR 101 683 (V1.1.1): "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; System Overview".

[8] ETSI TS 100 916: "Digital cellular telecommunications system (Phase 2+); AT command set for GSM Mobile Equipment (ME) (3GPP TS 07.07 version 7.6.0 Release 1998)".

[9] IEEE 802.15: "IEEE Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN - Specific Requirements - Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)".

[10] ITU-T Recommendation V.250 (05/99): "Serial asynchronous automatic dialling and control".

[11] ISO 9999 (1998): "Technical aids for disabled persons - Classification".

[12] ISO/IEC 6429 (or ECMA-48): " Information technology - Control functions for coded character sets".

[13] ISO/IEC 10646-1 amendment 2: " Information technology - Universal Multiple-Octet Coded Character Set (UCS) - Part 1: Architecture and Basic Multilingual Plane".

[14] ICTSB Project Team: "Design for All", CEN/ISSS (2000).

[15] ANSI/TIA/EIA-232E: "Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange".

[16] "Specification of the Bluetooth System; Volume 1; Core" Revision 1.1.

NOTE: Available at http://www.bluetooth.org.

[17] "Specification of the Bluetooth System; Volume 2; Profiles" Revision 1.1.

NOTE: Available at http://www.bluetooth.org.

[18] "Universal Serial Bus Specification"; Compaq, Hewlett-Packard, Intel, Lucent, Microsoft, NEC and Philips; Revision 2.0; 27 April 2000.

[19] "VT100 User Guide"; Digital Equipment Corporation; EK-VT100-UG-003.

NOTE: Available at http://www.vt100.net.

[20] "VT330/VT340 Programmer Reference Manual; Volume 2: Graphics Programming"; Digital Equipment Corporation; EK-VT3XX-GP.

NOTE: Available at http://www.vt100.net.

3 Definitions and abbreviations

3.1 Definitions

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

Assistive technology device: device used by a disabled person to prevent, compensate, relieve or neutralize any resultant handicap and which has the ability to interface to an ICT device

AT: two character abbreviation used to start a command line sent from terminal equipment to a terminal adaptor

Bluetooth: wireless technology enabling secure transmissions of both voice and data

Design for All: design of products to be usable by all people, to the greatest extent possible, without the need for specialized adaption

ICT device: device for processing information and/or supporting communication which has an interface to communicate with a user

3.2 Abbreviations

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

ADPCM	Adaptive Differential Pulse Code Modulation
ASCII	American Standard Code for Information Interchange
AT	ATtention
CI	Common Interface
DCE	Data Communications Equipment
DECT	Digital Enhanced Cordless Telephony
DECT	Digital European Cordless Telecommunications
DTE	Data Terminal Equipment
GPS	Global Positioning System
ICT	Information and Communications Technology
ICTSB	ICT Standards Board
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IrDA	Infrared Data Association
ISM	Industrial, Scientific and Medical
ISO	International Standards Organization
MMI	Man Machine Interface
MPEG	Motion Picture Experts Group
NTSC	National Television Standards Committee
PAL	Phase Alternate Line
PC	Personal Computer

PPP	Point-to-Point Protocol
SECAM	SequentiellE Couleur Avec Memoire
SMS	Short Message Service
TCP/IP	Transmission Control Protocol/Internet Protocol
USB	Universal Serial Bus

4 Overview

The population of Europe is ageing and the number of people with handicaps and disabilities is also increasing. At the same time there is a growing recognition of the need to integrate older people and people with disabilities into society by enabling them to remain independent for as long as possible. Information and Communications Technologies (ICT) play an important part in this integration process.

Taking the needs of this broader spectrum of people into account in the design process is called "Design for All", or "Universal" or "Barrier free" design (terms more often used in the United States). The philosophy behind Design for All is to ensure that mainstream equipment and services can be used by a wide range of users, including older adults and people with disabilities. The philosophy is best summarized in the definition of Design for All given by the ICTSB Project Team [14]: "The design of products, services and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."

Where a Design for All solution is not reasonably achievable, one possible solution is the provision of a technical interface to permit the use of a so called "assistive device" to fill the gap between the needs of the user interface of the device and the abilities of the user. All users would benefit from standards for these interfaces so that one assistive device, e.g. a display for the presentation of information in large letters, can be used for the widest possible range of products from different manufacturers. Assistive technology is thus used to modify the method of inputting information to or receiving information from a piece of mainstream technology.

Assistive technology is required by a user of ICT technology whenever the person's disability is such that they cannot operate the technology safely and efficiently. The increasing use of the Design for All philosophy should mean that the majority of disabled people will not require assistive technology but will be able to use mainstream technology successfully.

There are many factors that determine whether an individual requires mainstream or assistive technology to carry out any particular information or communication task. These factors include the nature and type of their disability as well as their access to information and to finance and their personal interest and motivation. A person may require assistive technology to carry out a particular task with an item of ICT equipment but not require it for a different task.

Improvements in neonatal survival have led to a growth in the number of young people with multiple minor disabilities. The overall effects of these disabilities can be difficult to assess as they are not a simple sum of the individual minor effects.

Under pressure of cost reduction, there is a growing tendency towards automation of many activities and many ticket machines and entry barriers are today unmanned. This can create increasing problems for disabled users, whose rights to participate in the normal activities of society should not be excluded by lack of required manual assistance. In general, disabled users should not be barred from equal access by the growing dependence on ICT in many areas of life. For example, any use of electronic voting should not prejudice a disabled person's right to vote.

5 User Aspects

5.1 User requirements

5.1.1 General

Designers should incorporate features in the standard product which will enable people with disabilities to use ICT products and services. This is the "Design for All" concept.

If "Design for All" is unable to provide an acceptable solution, then it will be necessary to incorporate a standard method of connecting the user's own device which has an appropriate user interface.

If neither of these approaches provides a satisfactory solution, then special equipment will be needed.

It must be remembered that inclusive design is not just adding an extra feature to a product to meet the perceived needs of a disabled user. It is a process, like quality, which has to be considered at every stage in developing a new product or service. This requires companies to promote a culture of inclusion within their organization. It also requires detailed technical guidelines on the design features required by the various groups of disabled users.

The ICT equipment should be designed in such a way that:

1) A person who is operating the device via assistive technology can use all of its relevant functions.

2) It can be easily and simply connected to the assistive technology device.

3) It has a standard method of interfacing with the assistive technology device and uses standard control commands.

4) It is designed to maximize the number of people who can operate it with standard assistive technology devices.

In some cases when using assistive technology with some ICT devices some additional training may be needed as some feedback may not be accessible to the user.

5.1.2 Who Requires Assistive Technology?

Although the requirements of most people with disabilities should be met by Design for All, there will be instances when the Design for All methodology has not been able to bridge the gap between equipment needs and user capability. A person with any disability will require assistive technology to use ICT equipment whenever they:

- Cannot operate the controls (for instance because of their physical disability).
- Cannot obtain information from the device (for instance because of their sensory disability).
- Cannot understand how to operate the device (for instance if they have a cognitive disability).

There may also be occasions where the operation of the device would be possible but would cause the user pain or take too much effort. A number of other factors may also determine whether a person will require assistive technology rather than Design for All. These are as follows:

5.1.3 What is asked for?

A survey was carried out of professionals working in the disability field across Europe (see annex A) to find out if there was a consensus on which disabled people would require assistive technology, which technology they would require it with and what factors would determine it's use. The numbers of people surveyed and the varying levels of knowledge and types of experience meant that the results were not definitive, but they do give an overview of the current state of knowledge and user expectations.

The survey referred to assistive technology, which is used to enable people to use current and future Information and Communication Technology (ICT) devices such as mobile telephones, computers and cash dispensers. For instance by using their personal assistive device such as Braille or large character display or a sticky key keyboard to interact with a device.

The two main results from the survey were as follows:

1) There was a range of answers to the question of who should be using assistive technology rather than Design for All but the vast majority of respondents felt that assistive technology should only be required by users with complex needs or multiple disability. This means that for instance:

   A ticket machine should provide its operational information either audibly for somebody with a visual impairment or visually for somebody with a hearing impairment but a deafblind person would need to provide their own assistive device (Braille keyboard and display) to operate it. Of course the ticket machine should be designed to be at the correct height to be operated by a person in a wheelchair. So therefore a hearing impaired wheelchair user should be able to operate the machine independently as the requirements for both of their impairments would be met.

2) Technology needs to be designed for mainstream use and for special use. The example given for this was GPS technology which has great potential benefits for blind and partially sighted people, but the technological requirements for a blind or partially sighted pedestrian are different from the requirements for a sighted car driver.

5.2 User handicaps

5.2.1 General

User handicaps are dealt with in detail in EG 202 116 [6], Human Factors guidelines for ICT products and services; Design for All which describes the characteristics of a wide range of disabled users and gives details of their impairments and the resulting handicaps.

The disabilities that have direct impact on the successful use of ICT products and services [14] include:

- Sensory abilities such as seeing, hearing, touch, taste, smell and balance.
- Physical abilities such as speech, dexterity, manipulation, mobility, strength and endurance.
- Cognitive abilities such as intellect, memory, language and literacy.

Allergies can also be a significant factor in some products.

5.2.2 Sensory disabilities

5.2.2.1 Sight

A person who is blind or partially sighted will have problems carrying out tasks which require vision. The vision loss may be total or the impairment may be less severe.

Design for All should ensure that any display on an ICT device should be configurable to suit the requirements of the user, particularly with respect to text size and colour. Provision should be made to permit an assistive device such as a Braille reader or a text to speech converter to be fitted.

Publicly accessible equipment should offer alternative display modalities to make them accessible to blind users who have to rely on hearing and touch.

5.2.2.2 Hearing

A person with a hearing loss may have a general hearing loss or may have lost a certain band of frequencies. The type and severity of their hearing loss will determine their ability to hear speech.

Design for All should ensure that inductive coupling facilities are available at all public terminals and on fixed telephones. Provision should be made to permit the connection of an assistive device such as a flashing light ringer.

A person who is deaf/blind will need to use a Braille reader and may also wish to use a Braille keyboard as an assistive device.

5.2.2.3 Touch

A person with an impaired sense of touch may find it difficult to use a touch pad on a computer.

Design for All should ensure that equipment does not require fine adjustment and that surfaces are free from sharp corners.

5.2.2.4 Taste and smell

Taste and smell are closely related and are used together to identify a range of flavours which can normally be distinguished. At the moment, neither of these senses has much applicability to the ICT environment although with future developments they may become significant.

At present, the only assistive technology for these senses is for the warning of noxious gases probably through a standard interface to an ICT device used in the domestic environment.

5.2.2.5 Balance

The ability to avoid falling by maintaining balance is dependent on a complex system which requires the co-ordination of visual stimuli, feedback from the balance mechanism in the inner ear and the appropriate movements of limbs. Most activities require the control of balance.

Design for All should ensure that apparatus required to be operated when standing up benefits from the provision of an available grasp to provide additional stabilizing support.

Public terminals should provide parking places for walking sticks.

5.2.3 Physical disabilities

5.2.3.1 Speech

For ICT products and services, speech is the most important sound produced by the voice. Speech production occurs in the mouth and larynx and depends on the co-ordinated action of many muscles.

Many assistive devices may rely on speech recognition for their operation.

5.2.3.2 Dexterity

Dexterity is defined as skill of manipulation and implies co-ordinated hand and arm use to pick up and handle objects, manipulating and releasing them using the fingers and thumb of one hand. Significantly, and from its Latin derivation, it can also mean right-handedness. It is not easy for dexterity impaired users to hold down multiple keys simultaneously. Severe dexterity problems may be assisted by voice control of the device, although some difficulties such as tremor are often associated with speech difficulties.

Design for All should ensure that apparatus is easy to control.

People with impaired dexterity may use alternative assistive input devices connected through the standard interface.

5.2.3.3 Manipulation

Manipulation is closely allied to dexterity and is conventionally defined [1] to relate to activities such as carrying, moving and manipulating objects and includes actions using legs, feet, arms and hands: reaching, lifting, putting down, pulling, pushing, kicking, grasping, releasing, turning, throwing and catching.

5.2.3.4 Mobility

Mobility problems can extend from small difficulties in movement to being confined to a wheelchair or being bedridden. Some mobility impaired users may have small or missing limbs. Common difficulties caused by ageing include limited ability to bear mass on the legs, reduced walking speed, restricted movement in the joints of arms legs and spine and difficulties in carrying out controlled and co-ordinated movement.

Design for All should ensure suitable space around public terminals to permit free and unimpeded access to mobility impaired users. Such terminals should be located to allow for wheelchair approach and manoeuvring. Mobility impaired users may benefit from wireless interfaces for input and output to ICT devices.

5.2.3.5 Strength and endurance

Strength relates to the force generated by the contraction of a muscle or muscle group and can be the force exerted with a specific part of the body on a specific object. It also depends on endurance or stamina (the capacity to sustain such a force) and can be related to heart and lung function.

Design for All should ensure that controls are easy to use.

In some cases a wheelchair or walking stick may be used as an assistive device and public terminals should make suitable provision.

5.2.4 Cognitive disabilities

5.2.4.1 Intellect

Intellect is the capacity to know, understand and reason. Conditions, which lead to progressive intellectual decline such as dementia and Alzheimer's disease, are more prevalent with older people.

Design for All should offer simple icons and abbreviations and graphic instructions.

A person with intellectual impairment may be able to operate ICT devices with some a personal input/output device coupled through a standard interface.

5.2.4.2 Memory

Failing memory affects people's ability to recall and learn things and may also lead to confusion. Either or both short term and long term memory can be affected.

Design for All should ensure simple input interfaces which do not burden the memory.

People with impaired memory may use alternative pre-programmed input devices connected through the standard interface.

5.2.4.3 Language and literacy

Language and literacy are the specific mental functions of recognizing and using signs, symbols and other components of language. Dyslexia is often considered an impairment of language, although there is some evidence that it can be classed as a defect of vision. Dyslexic people of all ages have difficulty with reading and writing.

People with impaired language and literacy may use alternative input/output devices using picture or Bliss symbols instead of text, connected through the standard interface.

6 ICT Device aspects

6.1 General

Assistive devices need to be used in cases when the input and output facilities of ICT devices are unable to match the abilities of specific users. It is therefore necessary to characterize the input media and their possible replacements in assistive devices in order to define the data that need to be transferred between ICT device and assistive device. Table 1 describes standard input media and their possible replacement while table 2 lists the respective output media. Also listed is the reason for the replacement, i.e. the special need of users who use these assistive devices.

Table 1: ICT input media

Keys (keyboards, keypads)

Assistive Device: replacement media	Reasons for replacement/special needs
Alternative keys with different characteristics (Larger, softer, more space between keys ....)	Motion Control Problems, missing limbs
Qwerty-Keypad	Cognitive/motion constraints, deafness (Textphone)
Voice Input (Controls)	Motion control problems, missing limbs
Speech to Text	Motion control problems, missing limbs
Alternative keyboards (e.g. Arabic)	Language Disabilities
Touchpads	Cognitive Disabilities, Pointing with tongue, etc.

Voice input (microphone)

Assistive Device: replacement media	Reasons for replacement/special needs
Text-to-speech (for communication)	Aphonia, aphasia
Text (for controls)	Aphonia, aphasia
Pointing device	Aphonia, aphasia and motion impairment

Pointing devices

Assistive Device: replacement media	Reasons for replacement/special needs
Text input	Motion impairment, control impairment
Speech input	Motion impairment, control impairment
Alternative Pointing Device (e.g. for use with tongue)	Motion impairment
Cursor Keys	Motion control impairment

Table 2: ICT output media

Visual Display

Assistive Device: replacement media	Reasons for replacement/special needs
Larger display	Limited eyesight
Display with Colour Conversion	Colour-Blindness
Braille Pad/Braille Display	Blindness
Speech (Text to speech device)/Audio	Blindness
Vibra	Deaf-blindness

Audio Output

Assistive Device: replacement media	Reasons for replacement/special needs
Vibra	Deaf-blindness
Visual	Hard-of-hearing (amplification of signals)
Amplifier/attenuators	Hard-of-hearing
Transposers	Disability to hear certain frequencies
Speech to text (possibly with Braille extension)	Deafness, Deaf-blindness

6.2 ICT Device input requirements

The input required by ICT devices can be characterized by the way the information is entered into the device:

- Text and/or control commands typed on a keyboard, the keys either being used for character input or as function keys. On mobile phones one of the standard ways of text input is by multiple key clicks on a number input keypad.
- Text and/or command input using voice and a microphone.
- Voice or video input to be transmitted to another ICT device without interpretation in the ICT device.
- Position information being input by means of a pointing device (mouse, keypad, touchscreen). This information is either being input as a pair of numbers representing the x- and y-co-ordinates of a position on a screen or, alternatively, as a list of pairs of x- and y-co-ordinates representing a curve being input with the pointing device.

The minimum Man machine Interface (MMI) necessary for input to an ICT device consists of a number of keys for text and command input as well as either a pointing device or a set of cursor keys to control the focus of the input.

6.3 ICT Device output capabilities

The standard media for representing output on an ICT device are:

- display-screens for the display of text, graphics and/or video information;
- loudspeakers for the presentation of audio communication, spoken text or state information;
- light emitting diodes for the presentation of state information like e.g. on/off or caps-lock on a keyboard;
- tactile output using a vibra system (e.g. for signalling of incoming calls in mobile phones.

The minimum MMI necessary for the output from most ICT devices must be capable of presenting textual, graphical and state information using audio and visual output media.

7 Assistive devices

7.1 Classification of existing devices

A person with a severe disability, unable to be dealt with by Design for All techniques will require assistive technology that compensates for their disability and enables them to use ICT equipment easily and safely. They will require the equipment for daily living tasks, education and employment. Current assistive technology is classified in the international standard ISO 9999 [11] which gives a classification of technical aids for disabled persons, restricted to those technical aids which are used mainly by an individual.

The standard is limited at the present time to the technical assistances mainly used individually by a handicapped person. The following points are specifically excluded from the applicability of this international standard:

- articles used for the installation of the technical assistances;
- solutions obtained by the combination of technical assistances belonging to other classifications;
- drugs;
- technical assistances and instruments of strictly medical use;
- formation with the handling of the technical assistances;
- financial assistance.

The technical assistances for public transport and the accessibility of the buildings are excluded from ISO 9999 [11] but could, thereafter, be included.

The standard lists only the names of devices and does not give any definitions. Although it covers a vast number of devices ranging from abacuses and abdominal hernia aids to zip pullers and zippers, only a few of the devices listed in that standard have the potential to be interconnected to information and communication technology systems. These are listed in table 3 together with their codes according to the ISO 9999 [11] classification system.

Table 3: Relevant Assistive Devices in ISO 9999 [11]

Classification code	Description
12 39 06	Electronic orientation aids
12 39 09	Acoustic navigation aids (sound beacons)
21 06 03	Image enlarging video system
21 06 06	Character reading machine
21 09 03	Input units (e.g. speech recognition)
21 09 06	Keyboard and control systems
21 09 09	Printers and plotters (e.g. Braille)
21 09 12	Displays
21 09 15	Devices for synthetic speech
21 09 27	Software for input and output modification
21 15 09	Dedicated word processors
21 15 15	Electric Braille writers
21 24	Aids for drawing and handwriting
21 33 09	Decoders for videotext
21 33 12	CCTV
21.36 06	Mobile telephones and car telephones
21 36 09	Text telephones
21 36 10	Visual telephones and videophones
21 42 09	Portable dialogue units
21 42 12	Voice generators
21 42 15	Voice amplifiers
21 45	Hearing aids
21 45 15	Tactile hearing aids
21 48 03	Door signals
21 51 03	Personal emergency alarm systems
21 51 06	Attack alarms for epileptics
21 51 09	Fire alarms
24 09	Operating controls and devices
24 12	Environmental control systems

The list in table 3 cannot be considered to be exhaustive but it gives some indication of the extensive range of possibilities for interconnecting assistive devices to ICT systems. As can be seen, in some cases the assistive device may be a mainstream device normally used for another purpose (e.g. a mobile telephone).

7.2 Information requirements

The information produced or presented by the different types of assistive devices corresponds directly to the information normally required or produced by the ICT devices with which the assistive devices are coupled. These types of information are characterized in clauses 6.2 and 6.3. The information to be exchanged between an ICT and an assistive device is described in clause 8.

8 Information to be exchanged

8.1 General

In most cases the requirement for an assistive device is either to produce output from the ICT system in a different modality (e.g. to convert text on a screen to speech output) or to produce an enhanced version of the same modality (e.g. larger characters on a high contrast display). In other cases the requirement may be for the modification of characteristics of signals which are not usually under user control (e.g. requesting more time for crossing at pedestrian controlled traffic lights).

Table 4 indicates the types of information to be exchanged between an ICT system and an assistive device. The information is divided into:

- data, which can be further subdivided into:
  - control and status information to synchronize the assistive device with the ICT device;
  - text;
  - graphics;
- audio;
- video.

Table 4: Examples of the type of information to be exchanged with an assistive device

Assistive device/service	Data			Audio	Video
	Control and status	Text	Graphics		
Braille display	⇔	→			
Tactual graphics display	⇔	→	→		
Synthetic speech display	⇔	→			
Enhanced visual display	⇔	→	→		
Keyboard/pointer	⇔	←	←		
Speech recognition	⇔	←			
Hearing aid	⇔			→	
Tactile hearing aid	⇔			→	
Alarm/monitor system	⇔			→	→
Smart house	⇔	⇔	⇔	⇔	⇔
Navigation system	⇔	⇔	→	→	→
NOTE 1: → indicates information to assistive device; ← indicates information from assistive device; ⇔ indicates information in both directions. NOTE 2: Some systems may use fewer modes than the possible ones indicated.					

8.2 Control and status signals

Control signals are signals such as the simple on/off function, exchanged between the assistive device and the ICT device in order to set up the basic device functions. Status signals describe the condition of the device and could include device identification information sent from the assistive device to identify its characteristics so that a suitably intelligent assistive device could configure itself appropriately.

In a general ICT environment, control signals would include the mouse/pointer output and even a translated speech command from a voice operated assistive device. In a communications environment signals transmitting number information would be considered control signals. In an alarm system or a smart house control signals could comprise inputs from a range of sensors.

In a general ICT environment, status signals from the processor could indicate its readiness to operate or accept signal input. In a communications environment, signals such as busy or ringing would be considered status signals. In an alarm system or a smart house status signals could comprise outputs from the central controller indicating e.g. the alarm status.

8.3 Communication signals

For the purposes of this report, communication signals are assumed to be the fundamental information intended to be input to and output from the ICT device such as speech, text or video information. This particularly applies in a telecommunications environment but could also apply, for example, to a recording device.

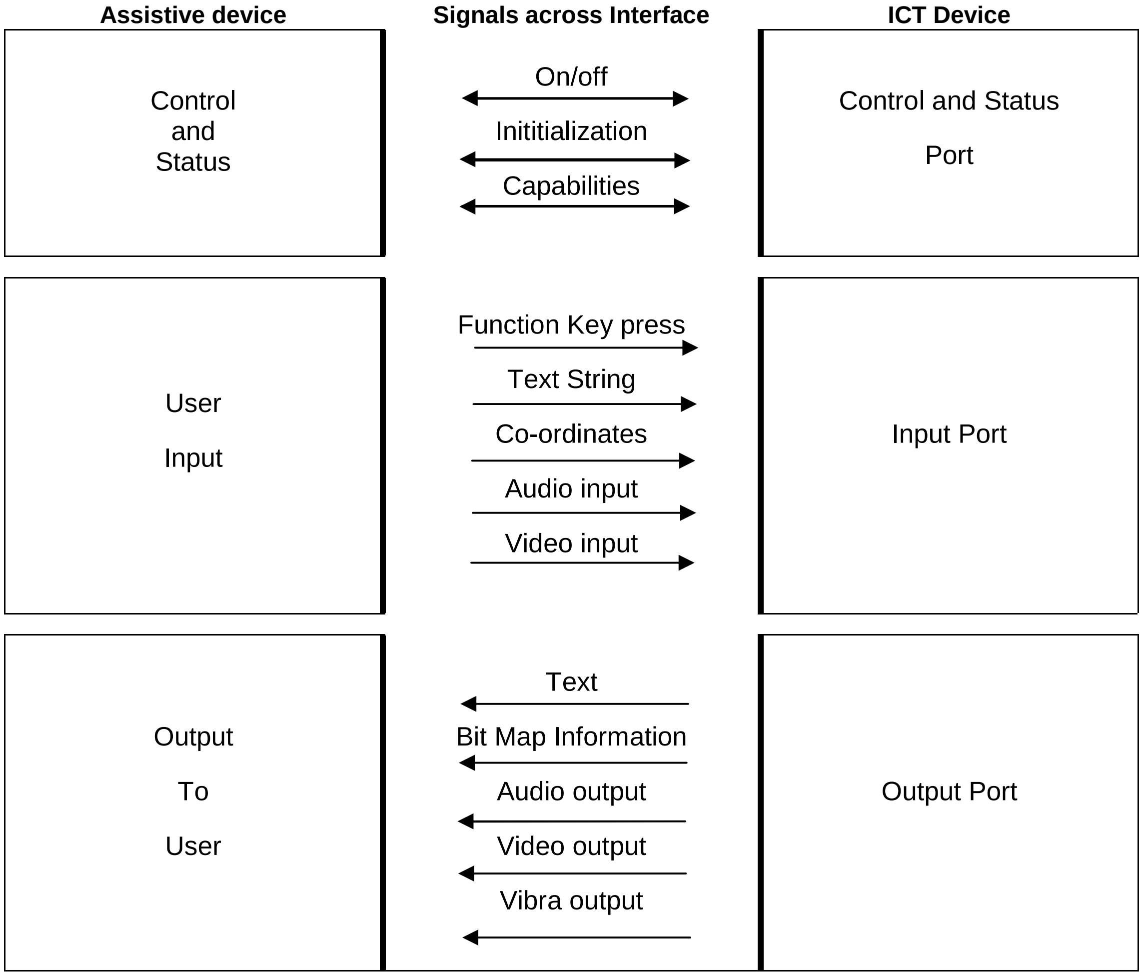

Figure 1: Information exchanged between Assistive technology device and ICT device

9 Interface transmission technologies

9.1 Wired Interconnection Technologies

9.1.1 RS-232 (plain serial data)

RS-232 is an interface designed in the 1960s for communication between a dumb ASCII terminal and a modem. For many years it has been the standard interface to interconnect computers, terminals, printers, punch-card readers, scanners, mice, etc. There are two variants:

- A 3-wire variant containing a send, a receive and a ground wire;
- A 6-wire variant containing 3 additional wires for hardware handshaking.

RS-232 typically supports speeds up-to 115 kbit/s. Communication is point-to-point. RS-232 does not provide powering. However, very low power (<10 mW) devices can sometimes be powered by the handshaking signal.

RS-232 only provides a means of transporting bytes from one end of the interface to the other. It does not care about the meanings of the data. The protocol run on top of RS-232 determines the meanings of the data passed over the interface.

RS-232 is very suitable to connect assistive data devices. However it is not suitable for voice. Simplicity is the big advantage of RS-232.

9.1.2 Plain analogue audio

The simplest way of connecting audio devices is to do it with a plain analogue one-directional 2-wire interface constituting out of signal and ground. A bi-directional interface would be two one directional interfaces, where the ground wire could be common.

For a plain analogue interface it is important that voltage levels and impedance's are specified. The specification of connectors is also a preferred requirement.

9.1.3 Video

For video there are many relevant param:

- The resolution. This is usually expressed in number of lines per frame.
- The number of frames per second.
- Whether interlacing is used or not. Interlacing means that not all lines are transmitted in all frames. E.g. in the odd numbered frames only the odd numbered lines are transmitted, and in the even numbered frames only the even numbered lines.

Depending on the requirements, the most obvious choices for video are:

- The interfaces used for connecting video camera's and recorders to TV sets. These interfaces are limited in resolution. In Europe 625 lines per frame/50 half-frames per second is used. North America and Japan 525 lines per frame/60 half-frames per second is used.
- Also on the physical level there are differences. It is possible to transmit red, green and blue over separate wire pairs. It is also possible to transmit luminance and modulate the colour in the luminance signal. Three different colour modulation schemes are used in Europe (PAL, SECAM-France and SECAM-East) and one other in North America and Japan (NTSC).
- The interfaces used for connecting monitors to PCs. These interfaces provide for a high resolution. Compatibility cannot be taken for granted here either (e.g. compatibility setting up overhead presentations with a beamer).
- Streaming video. Video is transmitted as MPEG streams over an Internet connection. A computer is necessary for decoding it.

9.1.4 USB (Universal Serial Bus)

USB is an interface used for connecting up-to 127 (slave) devices to a single host (master). The physical connection is a tiered star topology. The logical connection is point-to-point.

USB 1.1 supports speeds up-to 1.5 Mbit/s. USB 2.0, which is due to be released soon, supports speeds up-to 400 Mbit/s. USB provides limited powering (< 2 W).

A typical USB configuration is a PC acting as a host (master). A hub is connected to the PC. Several devices - called slaves - are connected to the hub. It is possible to connect another hub to the hub. A hub acts in one direction as a slave, and in the other direction as a master.

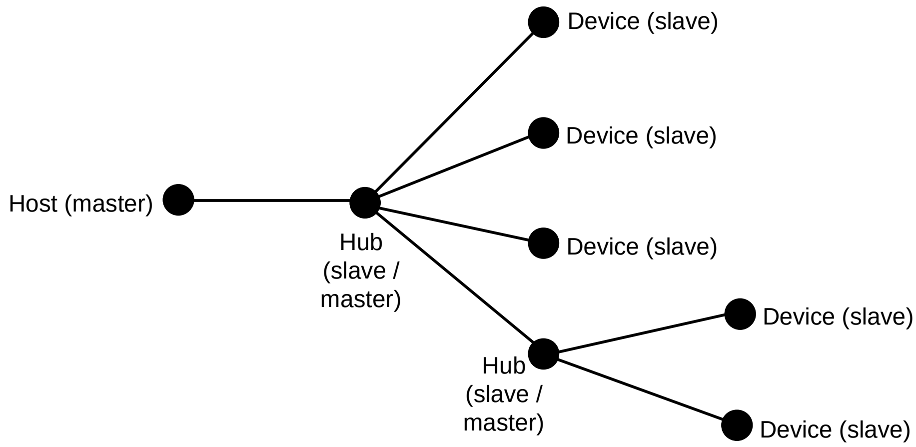

Figure 2: A typical USB configuration

All devices are accessed by a USB address, which is assigned when the device is attached. When a device is attached it provides on request of the host the following information:

- Information whose definition is common to all USB devices such as vendor identification, device class, power management capabilities;
- Vendor specific information.

The host initiates all data transfers. All devices are regular polled. Typically each device has a corresponding device driver at the host, which communicates with the device driver for the USB host adapter, which in turn communicates with the USB physical layer.

USB is often used to encapsulate other interfaces. It is possible for example to connect an RS-232 to USB converter to the USB bus of a PC. The application on the PC thinks it is talking directly towards an RS-232 port, but in reality the communication is going via the USB bus.

9.1.5 Others

ETS 300 679 [4] defines an interface for the direct electrical connection of telephones to hearing aids but there are difficulties in making the connection to modern hearing aids. Many years ago in I-ETS 300 245-1 [5] a wired electrical interface was defined for the connection of additional equipment to an ISDN telephone but this does not seem to have wide usage.

9.2 Wireless Interconnection Technologies

9.2.1 Overview

Various systems are under development for a range of applications (see table 5) but they have developed differently depending on what has been viewed as the primary application area. The systems generally use either infra-red or wireless signals to communicate short distances although simple inductive coupling is used to couple telephone earphones to hearing aids as specified in ETS 300 388 [3].

Table 5: Wireless Interconnection Technologies

Feature	HomeRF	802.11a	802.11b	Bluetooth	DECT	IrDA
Technology	Radio	Radio	Radio	Radio	Radio	Optical
Frequency	2,4 GHz	5 GHz	2,4 GHz	2,4 GHz	1,9 GHz	850 nm
Basic data rate bit/s	0,8/1,6 M	54 M	11 M	1 M	552 K	4 M/115 K
Range - metres	50	150	30	10	300	3
Max terminals	128	128+	128	8	12	10

The above figures should be treated with caution since they indicate maximum figures under ideal conditions, which may not be realized in real situations. The unlicensed Industrial, Scientific and Medical equipment (ISM) band at 2,4 GHz is used by a number of systems including microwave ovens; this band is international except that there are restrictions in its use in France, Spain and Japan. In an environment, such a conference hall, where there may be many notebook computers, mobile phones and personal digital assistants the data rate may be very low.

9.2.2 HomeRF

This system operates in the 2 400 MHz band with 100 mw transmit power at 50 hops/s which gives a range of about 50 metres in a typical home environment. It supports 1 Mbit/s data throughput with integrated TCP/IP networking protocols and a packet structure for use with Ethernet. It can provide up to four voice connections of a quality comparable to a wireline. It is based on 32 kbit/s ADPCM and DECT call processing. It includes power management for ultra-portable devices.

The primary application areas are for home automation, interconnecting computers, computer peripherals, computer network, and cordless phones. There are plans for making this system capable of communicating with Bluetooth systems. Future versions of HomeRF are predicted to be capable of speeds up to 20 Mbit/s and could be available within 2 years.

9.2.3 HiperLAN2

This radio system is developed by ETSI BRAN for local area networks and is applicable in business, home and public environments. HiperLAN2 [7] can provide up to 54 Mbit/s at the physical layer and operates in the 5 GHz frequency band (5,15 GHz to 5,35 GHz and 5,470 GHz to 5,725 GHz). The system uses Orthogonal Frequency-Division Multiplexing (OFDM). The medium access is based on Time Division Duplex (TDD)/Time Division Multiple Access (TDMA). The physical layer is harmonized with IEEE 802.11a but HiperLAN2 uses a centralized controller for medium access whereas IEEE 802.11a uses a distributed MAC protocol.

HiperLAN2 supports QOS (Quality of Service), provides access to various core networks like Ethernet, ATM, IEEE 1394 (FireWire) and 3G mobile networks. It also has advanced security features (authentication and encryption).

9.2.4 IEEE 802.11 family

This system was developed primarily for local and metropolitan area networks. The low level of security could be problematic in some applications.

IEEE 802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology.

IEEE 802.11 specifies an over-the-air interface between a wireless client and a base station or between two wireless clients. The IEEE accepted the specifications in 1997. The following later extensions have been developed:

- **802.11:** applies to wireless LANs and provides 1 or 2 Mbit/s transmission in the 2,4 GHz band using either frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS).

- **802.11a:** an extension to 802.11 that applies to wireless LANs and provides up to 54 Mbit/s in the 5GHz band. 802.11a uses an orthogonal frequency division multiplexing encoding scheme rather than FHSS or DSSS.

- **802.11b** (also referred to as *802.11 High Rate* or *Wi-Fi*): an extension to 802.11 that applies to wireless LANS and provides 11 Mbit/s transmission (with a fallback to 5,5 Mbit/s, 2 Mbit/s and 1 Mbit/s) in the 2,4 GHz band. 802.11b uses only DSSS. 802.11b was a 1999 ratification to the original 802.11 standard, allowing wireless functionality comparable to Ethernet.

- **802.11g:** applies to wireless LANs and provides 20+ Mbit/s in the 2,4 GHz band.

Standard	Frequency
802.11	2 400 GHz to 2 483,5 GHz
802.11a	5,15 GHz to 5,25 GHz 5,25 GHz to 5,35 GHz 5 725 GHz to 5 825 GHz
802.11b	2 400 GHz to 2 483,5 GHz

9.2.5 Bluetooth

Bluetooth is a standard for wireless accessory connections. It operates in the 2 400 MHz to 2 483,5 MHz ISM band, which is available world-wide for unlicensed use. Bluetooth has been designed to operate in noisy radio frequency environments by using a fast acknowledgement and frequency hopping at 1 600 times per second between the 79 channels so as to provide a robust link. Interference from other signals is avoided by hopping to a new frequency after transmitting or receiving a packet. It can transmit data both symmetric and asymmetric with a bandwidth of 1 Mbit/s (although the maximum asymmetric data rate is 721 kbit/s in one direction). It can be used to give three voice channels with 64 kbit/s synchronous links.

With the current specification, up to 7 slave devices can be set to communicate with a master device. Bluetooth supports speeds up-to 1 Mbit/s. The maximum range is 10 m but the range can be extended to 100 m with additional amplifiers. Each device in a piconet can be a member of more than one piconet at the same time. Each terminal can be aware of up to 255 other terminals. The frequency hopping system means that the system is reasonably secure.

The primary application areas have been considered to be interconnecting mobile phones, computers and PDAs. Secondary applications include smart housing and CANs (car area networks). There is considerable hype surrounding Bluetooth with promises of very low prices (some sources suggest figures as low as $5 per unit). Bluetooth 2 is likely to operate at about 5 GHz and have similarities to IEEE 802.11a.

The typical application for Bluetooth is cable replacement. Usually the Bluetooth radio is built into a small, low-cost microchip with very low power consumption. This enables low-cost implementations.

Bluetooth is supporting a number of standardized profiles, thereby ensuring the availability of a minimum functionality needed, as well as compatibility between devices:

- Audio (headset profile). This profile is used for connecting wireless headsets to a mobile telephone;
- Serial data communication (serial port profile). This profile mimics the serial cable between a laptop computed and a mobile phone;
- IP encapsulated in PPP (LAN access profile). This profile establishes a PPP connection. IP packages can be transported over this PPP connection. The lower layers of this profile are similar to the serial port profile.

9.2.6 DECT

DECT is an ETSI standard for cordless telephony, developed in the 1990s. About 50 million units have been sold. The standard is defined in the various parts of ETS 300 175 [2]. DECT operates in the 1 880 MHz to 1 900 MHz band. In Europe, Australia, Africa and parts of Asia, this spectrum is available for unlicensed DECT applications. However, in North- and South-America and in parts of Asia this spectrum is not available for DECT applications.

The typical application for DECT is a base station connected to the public or a private telephony network. The base station communicates with a handset, after configuration and set-up. Some base stations allow for the registration of multiple handsets, so forming a small cordless PBX. The maximum range for DECT is about 100 m.

In large enterprises, sometimes multiple base stations are connected to a PBX. The handsets can move from the coverage area of one base station into the coverage area of another, while maintaining a call *(hand-over).*

DECT aims to provide speech transmission at a quality comparable to the wired telephony service. In addition to voice calls it supports some data services like SMS, circuit switched and packet switched data. However, there are few commercially available implementations of this.

The DECT standard guarantees interoperability between similar devices from different manufacturers. For voice, this has proven to work well in practice. However, the few data implementations there are often do not interoperate well due to proprietary implementations and ambiguities in the standard. The market for standardized DECT data applications does not seem to have taken off.

9.2.7 IrDA

The infra-red spectrum is unregulated world-wide which overcomes one problem faced by the radio-based systems, but has the disadvantage it is directional and requires both ends to be in the same room. However in can provide symmetric two-way communication at up to 16 Mbit/s. Another significant advantage is that it is available now and is inexpensive. A problem is that the standards are not uniquely defined so equipment from one manufacturer is not always compatible with that of another.

10 Protocol stacks

It is common to describe the protocol of interfaces between ICT devices in a layered way in a form known as a stack. For example, the interface between a computer and a printer can be described with the following layers:

- A physical layer describing the interface to a physical layer such as a bundle of wires carrying electrical signals;
- A hardware control layer describing how a single byte of information can be transferred between the computer and the printer by manipulating the electrical signals passing across the physical layer;
- A printer language layer describing how the printer shall interpret the bytes it receives. E.g. some bytes command the printer to change font while other bytes are the text that is to be printed. Examples of this layer are Postscript and HP-PCL.

This interface is described in a graphical way in figure 3:

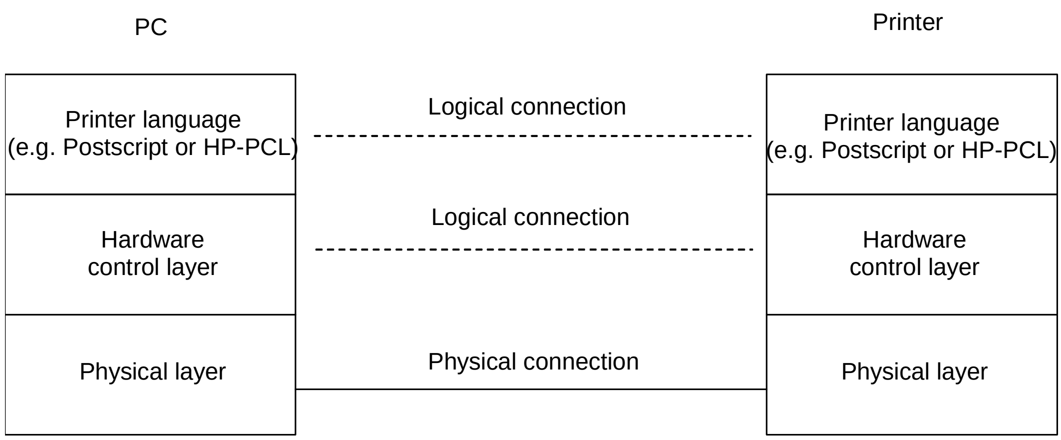

Figure 3: The interface between a computer and a printer

The physical layer connects the PC and the printer. The hardware control layer block in the PC talks with the hardware control layer block in the printer. The printer language block in the PC again talks with the printer language block in the printer.

If less detail in the interface description is needed two layers can be described together. If in the above picture the physical layer and the hardware control layer are the ones defined for the popular parallel interface, and the printer language is Postscript, the above picture could look like figure 4.

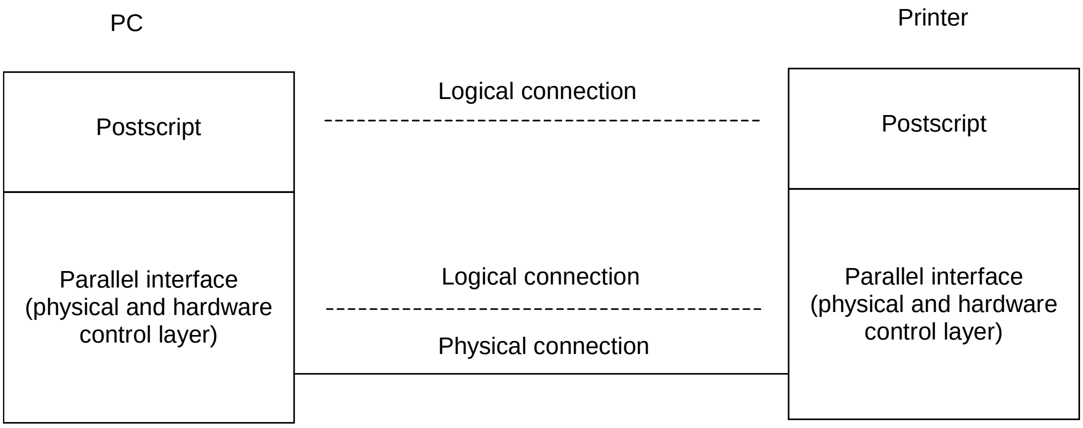

Figure 4: Simplified interface representation

It is quite possible to equip the printer with another physical interface, while using the same printer language. If the above printer had a USB interface instead of the parallel interface, to protocol stack picture would be as in figure 5.

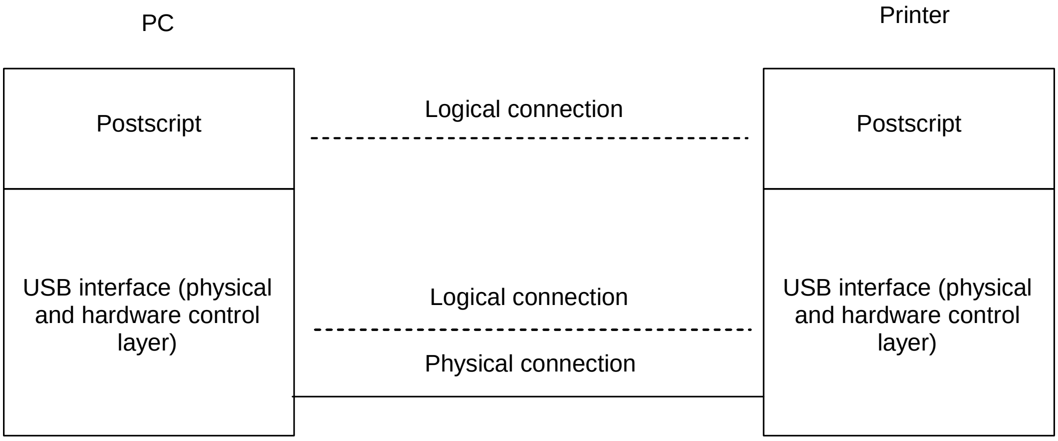

Figure 5: Using a USB interface

11 Recommended interfaces and protocols

11.1 General

The connections for assistive technology can be split into data, audio, and video.

These connections can be treated independently. Some assistive devices will need to support more than one type. In that case, several connection interfaces must be supported.

It is proposed that the simplest possible interfaces should be used as a basis. These can be carried over a number of, wired or wireless, transmission technologies, supporting these basic connections.

USB is the currently preferred solution for the wired interface, HiperLAN2 or the IEEE 802.11 family for wireless local area networking and Bluetooth (IEEE 802.15 [9]) for wireless personal area networking and access. DECT is not likely to achieve wide use due to limitations in its global availability.

11.2 Data

The data interface should be an RS-232. On top of the RS-232 interface, a protocol dependent on the type of assistive device must be run. If desired, this interface can be carried over either a suitable physical layer such as USB or Bluetooth (which are used in the present document as examples). This would give the protocol stack alternatives shown in figures 6, 7 and 8. In each case, the assistive device protocol would be the same.

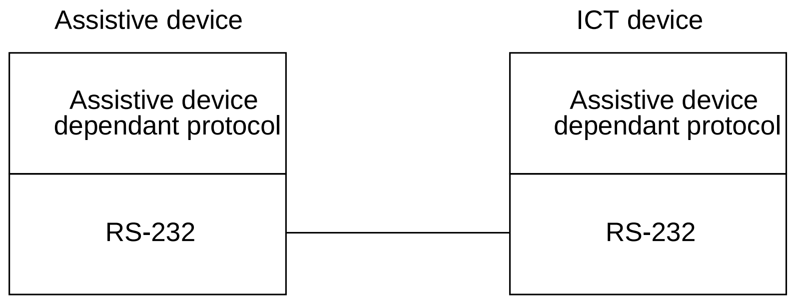

Figure 6: RS 232 protocol stack

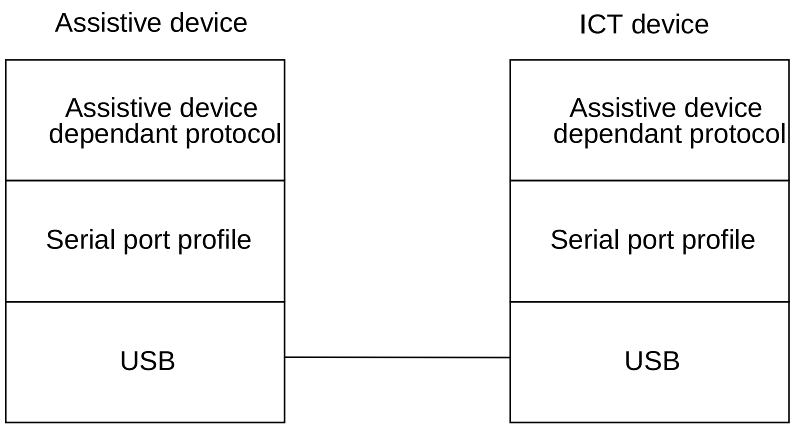

Figure 7: USB Protocol stack

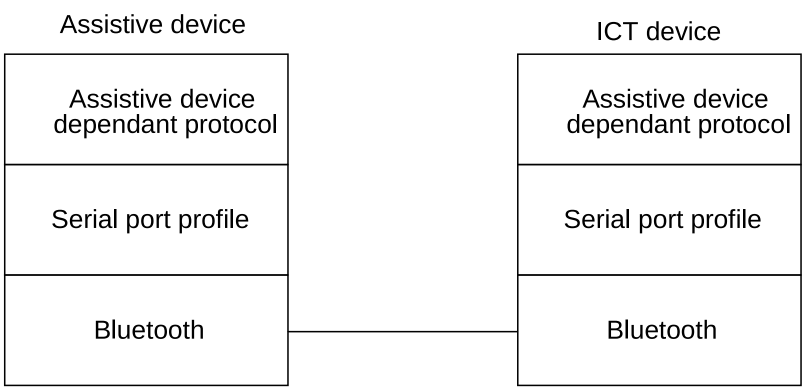

Figure 8: Bluetooth Protocol stack

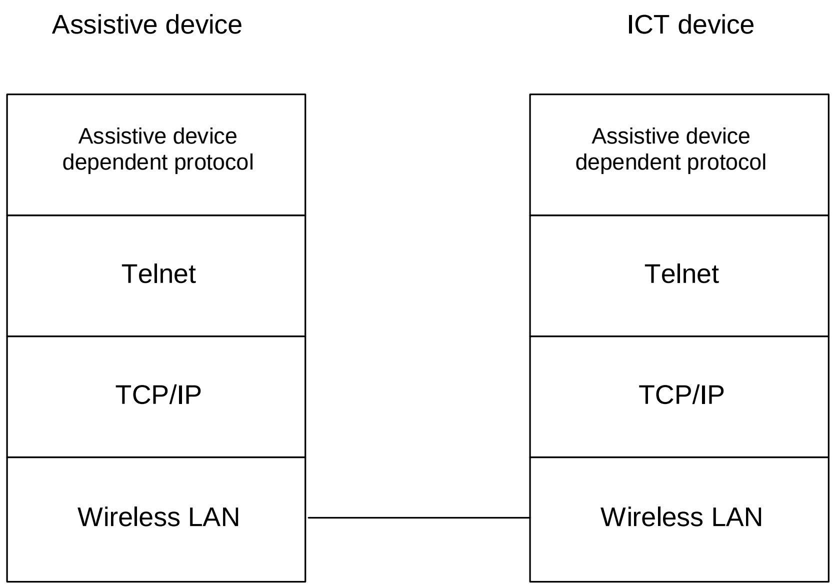

Figure 9: Wireless LAN Protocol stack

An assistive device using a basic RS-232 interface can be turned into one with a USB or Bluetooth interface by using off-the-shelf converters. Figure 10 shows how this works.

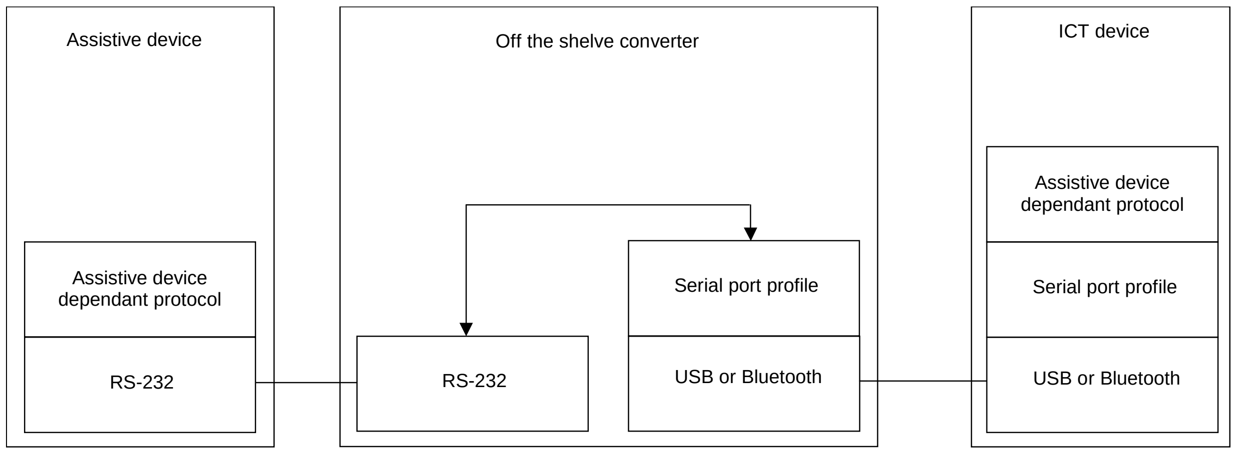

Figure 10: RS-232 interface transmission over USB or Bluetooth

11.2.1 Applicable requirements for data over RS-232

The interface should be in accordance with the EIA-232E specification [15] with the assistive device acting as Data Terminal Equipment (DTE) and the ICT device acting as Data Communications Equipment (DCE). DB9 connectors are recommended.

11.2.2 Applicable requirements for data over USB

The interface should be in accordance with the Universal Serial Bus Specification [18] with the assistive device acting as master (the host device) and the ICT device acting as slave.

11.2.3 Applicable requirements for data over Bluetooth

Data over Bluetooth should be in accordance with the serial profile as specified in volume 2 of the Bluetooth specification [17]. This profile specifies which parts of the Bluetooth core have to be implemented. The Bluetooth core is specified in volume 1 of the Bluetooth specification [16].

11.2.4 Applicable requirements for data over wireless LAN

The interface should be in accordance with the specifications available on http://standards.ieee.org/catalog/olis/index.html.

On the assistive device side, TCP/IP protocol and Telnet (RFC standards) should be used.

In addition to the above, on the assistive device side, IP addresses need to be allocated in the same range (object for further study).

11.2.5 Applicable requirements for assistive device dependant data protocol

In the telecommunications industry, the AT command set has become the standard protocol for the transfer of control and status information. The AT command set is defined in ITU-T Recommendation V.250 [10] and in TS 100 916 [8]. A few additional commands specific for assistive devices will have to be agreed with the ETSI technical body responsible for the present document. See the next clause for a proposed list of commands specific to the use of assistive devices.

Transfer of text should be carried out using UTF-8 character coding as defined in ISO/IEC 10646-1 amendment 2 [13]. Control escape sequences as defined in ISO/IEC 6429 [12] can be inserted in the text to facilitate things like clear screen and move cursor. The present document is a superset of the classical VT100 terminal manufactured by Digital Equipment Corporation in the late 1970s and the early 1980s, which was the de-facto standard for serial computer terminals. To improve interoperability it is recommended that ICT devices use only the original VT100 sub-set [19] of the ISO/IEC 6429 standard [12].

Transfer of graphics should be carried out using the ReGIS commands, as used in the VT330 terminal manufactured by Digital Equipment Corporation in the late 1980s. These graphic commands, which are an extension to the VT100 command set, are defined in [20].

Since only one serial connection is available for the transfer of control and status information, text and graphics, it should be possible to switch between the AT command mode used for exchanging control and status information, and the terminal mode used for exchanging text and graphics. This should be done according to the state diagram shown in figure 11.

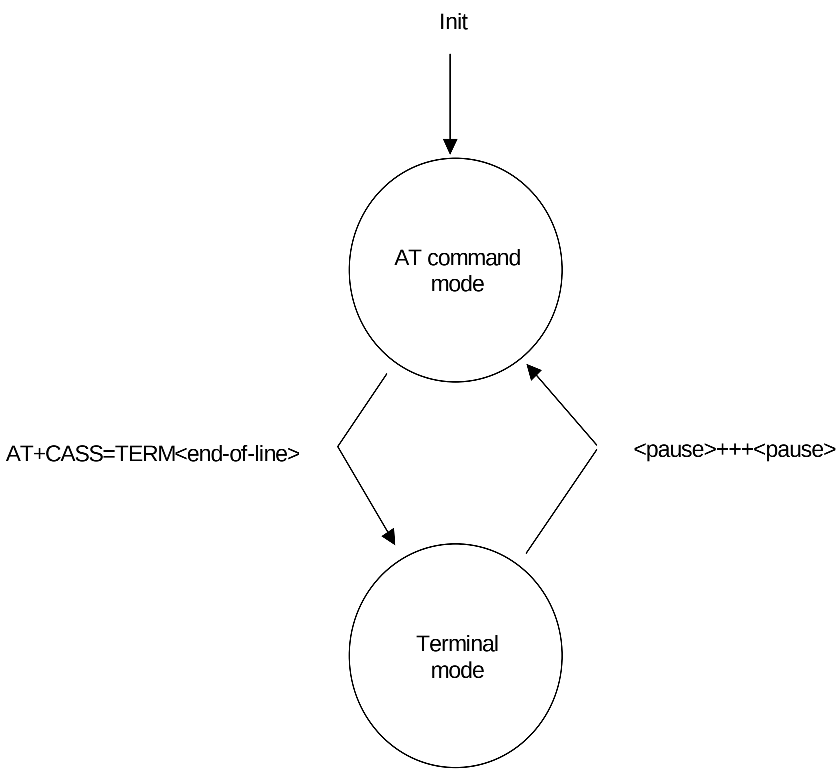

Figure 11: Switching diagram

In AT command mode the ICT device indicates it is ringing by sending every few seconds the string RING followed by an end-of- line. In terminal mode the ICT device indicates it is ringing by sending every few seconds the BELL character (ASCII 07).

11.2.6 Suggested assistive device specific commands

It is suggested that the following additional AT commands are defined for use by assistive devices:

Command	Possible response(s)
+CASS=<sub-command>[,<param>]	+CASS: <response> +CASS ERROR: <error code>
+CASS=?	+CASS: (list of supported <sub-command>s)

It is necessary that the definition of the +CASS (arbitrarily chosen where +C stands for the generic cellular prefix, and ASS stands for assistive device) command string is co-ordinated with the ETSI technical body responsible for the TS 100 916 [8]. Otherwise there would be a risk that this command string could be assigned for other purposes. If the +CASS command string is reserved for use by assistive devices, additional sub-commands can be added without co-ordination with the ETSI technical body responsible for the TS 100 916 [8].

11.2.6.1 Enter terminal mode

+CASS command with sub-command	Possible response(s)
+CASS=TERM	+CASS: TERM OK +CASS ERROR: <error code>

The +CASS=TERM command should put the data connection in ANSI text terminal mode. From now on everything written to the screen of the ICT device is copied to assistive device via the data connection, while all text send from the assistive device to the ICT device is interpreted as key-strokes.

Text should be coded according to the UTF-8 format as defined in ISO/IEC 10646-1 amendment 2 [13]. Additional functions like clear screen, move cursor, function key presses etc. be coded according to ISO/IEC 6429 [12].

To return to control mode, the assistive device has to send the escape sequence <pause>+++<pause>.

From text terminal mode, sending an escape sequence can enter graphics terminal mode. This is described in [20].

11.2.6.2 Increase or decrease time-outs

+CASS command with sub-command	Possible response(s)
+CASS=TOUT,<+n>/<-n>	+CASS: TOUT OK +CASS ERROR: <error code>

Multiply or decrease all time-outs with a factor n.

11.3 Audio

It is recommended that where an analogue audio interface is provided it should be similar to that in laptop PCs and PC audio cards.

If desired, this interface can be carried over either USB or Bluetooth. This would give the following protocol stack alternatives:

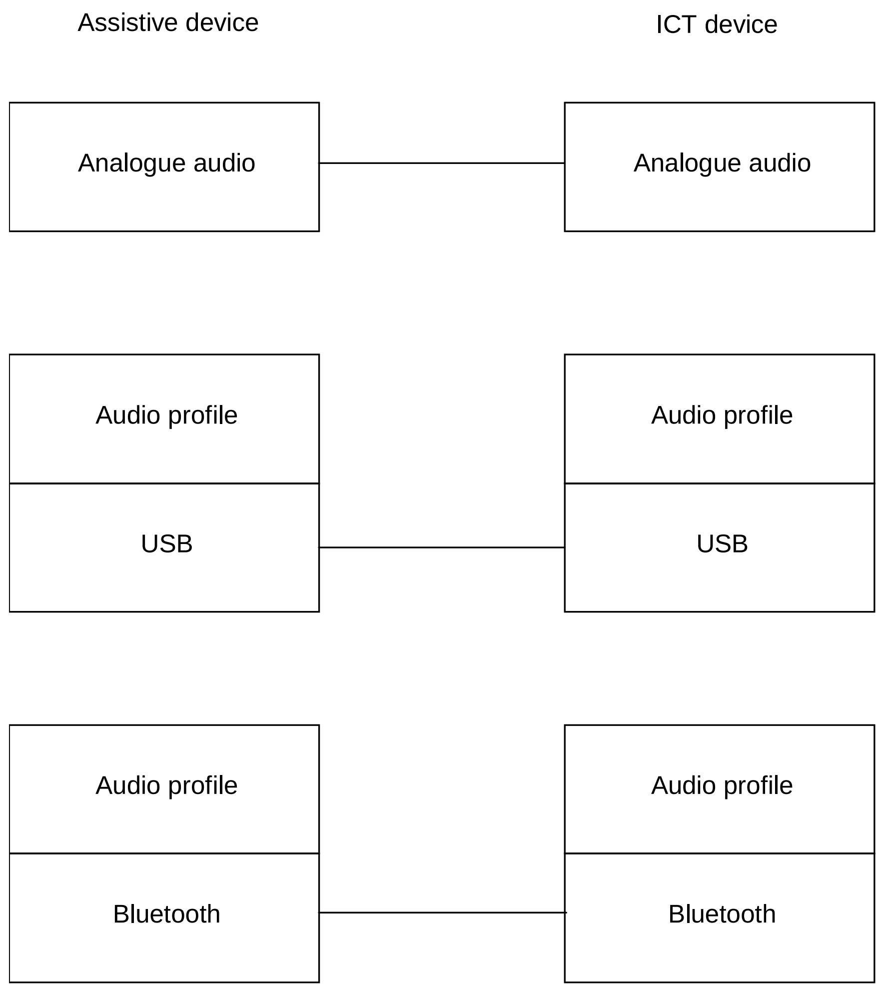

Figure 12: Protocol stack alternatives for audio

An assistive device using a basic analogue audio interface can be turned into one with a USB or Bluetooth interface, by using off-the-shelf converters. Figure 13 shows how this works.

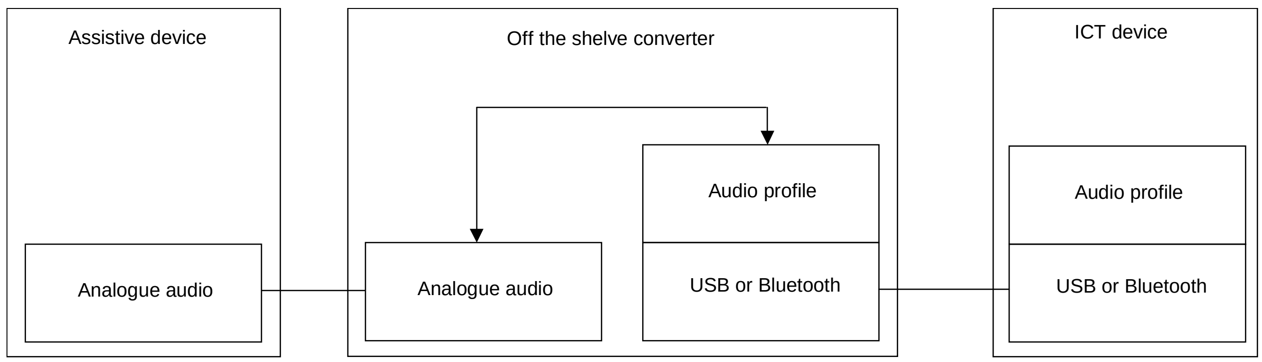

Figure 13: Analogue audio interface transmission over USB or Bluetooth

11.3.1 Applicable requirements for wired analogue audio

Standard 3,5 mm connectors should be used. ICT devices should be equipped with jacks (female). Assistive devices should be equipped with jacks. Cables should be fitted with plugs (male).

The electrical specification of a line audio input to the ICT device should be:

- Input impedance > 10 kΩ;
- Maximum input level 1 V_{RMS}.

The electrical specification of a line audio output from the ICT device should be:

- Output impedance < 1 kΩ;
- Maximum output level 1 V_{RMS}.

The electrical specification of a microphone audio input to the ICT device should be:

- Bias < 5,5 V_{DC} without load, > 2,0 V_{DC} with 0,8 mA load;
- Input impedance > 10 kΩ;
- Maximum input level 10 mV_{RMS}.

The electrical specification of a headset audio output from the ICT device should be:

- Maximum output power 100 mW into 32 Ω load.

NOTE: Line input/outputs are used to interconnect audio equipment not being microphones or headsets. The headset output can be used instead of the line output if the volume control is not set at it maximum level.

11.3.2 Applicable requirements for audio over USB

The interface should be according to the Universal Serial Bus Specification [18] with the assistive device acting as master (the host device) and the ICT device acting as slave.

11.3.3 Applicable requirements for audio over Bluetooth

Audio over Bluetooth should be according to the headset profile as specified in volume 2 of the Bluetooth specification [17]. This profile specifies which parts of the Bluetooth core have to be implemented. The Bluetooth core is specified in volume 1 of the Bluetooth specification [16].

11.4 Video

Due to the variations in technical param, their complexity and the quick development in the area, no proposal is presently made for video. However, there are many de-facto standards in this area.

12 Recommendations and conclusions

An *e*Europe community that allows everyone fair access to advanced information and communication media must include those citizens whose disabilities are such that they cannot use devices designed for all. For this group of users, often with multiple disabilities, it is crucial that affordable, effective and usable assistive devices be available.

These devices must be able to interact with a multitude of fixed and mobile ICT devices. For the development of these assistive devices, the standardization of the interfaces to ICT devices is a requirement. Standardization of these interfaces must begin at the earliest possible point.

For assistive devices to become affordable and effective, the significant players in each field need to agree on a set of protocols to be used in the communication between assistive devices and the relevant ICT devices. In general it is not necessary to develop either new protocols or new hardware interfaces. As exemplified in clause 11, the interface and protocol standards should be chosen from those already available so as to form a coherent set which covers all major aspects of information exchange between the two sets of devices.

The work to achieve this will include the upgrading of existing standards where the necessary commands do not exist, or the writing of new standards where no existing standard is relevant. Consensus on this set of interface standards must be reached in the appropriate standards fora in a process which involves manufacturers of mainstream devices, manufacturers of assistive devices and the groups representing the user with different special needs.

It is probable that normal commercial considerations will make it difficult to provide the resource necessary to derive an acceptable solution within an acceptable timeframe and it is therefore probable that special funding will be necessary to support these standardization activities. Most manufacturers of assistive devices are in the SME group. This funding will therefore be even more important if they are to participate in the standardization process.

When standards for interfaces and protocols have been established it is important that they are given the widest possible visibility so as to encourage their use. It is therefore proposed that the European Commission create and maintain a list of such standards on an assistive technology database in a similar manner to the Web Access Initiative.

The success of these standardized interfaces cannot be assured if they are promulgated only within the European community. It is necessary to reach international agreement on the suggested solution. Therefore it will be necessary for the working groups responsible for the standard definition to liaise with the relevant standardization bodies and industry fora throughout the world.

It is therefore proposed that a team be set up charged with the responsibility to perform the following actions.

- Create and maintain a public database of relevant interfaces and protocols.
- Identify the application areas where new work is needed.
- Stimulate and co-ordinate the development of the necessary standards and amendments.
- Make provision for the testing of the interoperability of new protocols and products.
- Identify areas where the new standards can improve the quality of life of elderly and disabled users.
- Disseminate the information to the interested parties.
- Stimulate and promote the use of the appropriate standards in ICT systems.

Annex A: Questionnaire sent to professionals working in the disability field

1) Design for All or Assistive Technology?

   Please can you tell me in what circumstances would people in the following categories require assistive technology to use information and communication technologies? Please answer for all categories that you have knowledge of.

   1.1) People with physical disabilities (including people with reduced mobility dexterity, reach, balance, strength, stamina and height).

   1.2) People with sensory disabilities (including people with reduced vision, hearing or reduced vision and hearing).

   1.3) People with cognitive disabilities (including people with learning disabilities and mental health problems).

   1.4) People with communication disabilities (including people who are Illiterate or who have speech impairment)

   1.5) People with multiple disabilities.

2) Type of Assistive Devices Required?

   What types of assistive technology do people in the following categories require? Please answer for all categories that you have knowledge of.

   2.1) People with physical disabilities.

   2.2) People with sensory disabilities.

   2.3) People with cognitive disabilities.

   2.4) People with communication disabilities.

   2.5) People with multiple disabilities.

3) What are the most important requirements for assistive technology (for instance weight, cost, portability etc) for people in the following categories? Please answer for all categories that you have knowledge of.

   3.1) People with physical disabilities.

   3.2) People with sensory disabilities.

   3.3) People with cognitive disabilities.

   3.4) People with communication disabilities.

   3.5) People with multiple disabilities.

4) What future developments in information and communication technologies will have particular relevance to people with disabilities?

5) Do you have any other comments on the future of assistive technology?

6) Can you tell me in your opinion at what degree of disability will a user have to use assistive technology rather than Design for All?

7) Your details?

Name:

Organization:

Town/City:

Country:

Email:

Thank you very much for your time and contribution.

Would you like to receive a copy of the results from this research: Yes/No.

If you know of anybody else who would be willing to answer these questions please tell me their name and contact details.

A large number of responses were received from 15 different countries. Acknowledgement is given to the following respondents, listed in alphabetical order:

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Annex B: Questionnaire sent to assistive device industry

The following questionnaire was sent to a representative sample of the manufacturers and designers of assistive technology devices:

"Many information and communication technology (ICT) industries are working on making their products usable by disabled and elderly users. When inclusive design does not meet all the users' needs, it will be necessary to use assistive devices. Currently there is little standardization of the interface between assistive devices and ICT systems.

1) In your opinion, would it be useful for there to be standard interfaces between assistive devices and ICT systems?

2) What features should be covered by such a standard?

3) Should the standard protocols be independent of the transmission system (e.g. infra-red, Bluetooth, hard wire connection)?

4) What other aspects should be considered when preparing this standard?

I look forward to hearing from you."

A large number of responses were received. Acknowledgement is given to the following respondents, listed in alphabetical order:

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Web Sites

A Assistive Technology

- **AbilityHub** *www.abilityhub.com:* AbilityHub is an assistive technology related web site for people with a disability who find operating a computer difficult.
- **AbleData** *www.abledata.com:* ABLEDATA provides information on assistive technology and rehabilitation equipment available within the United States.
- **AssistiveTech** *www.assistivetech.net:* An American site under development which lists assistive devices.
- **COST 219bis** *www.stakes.fi/cost219:* This site is concerned with access to telecommunications by disabled and elderly people.
- **Disability Living Foundation** *www.dlf.org.uk:* DLF lists equipment available, mainly for physically disabled persons.
- **Foundation for the Advancement of Assistive Technology** *www.fastuk.org:* FAST aims to facilitate the advancement of assistive technology by liaising between research and development institutions, manufacturers, service providers and end-users.

- **Kyoyo-Hin Foundation** *http://www.kyoyohin.org/eng*: This Japanese Foundation is concerned with the development of products and services that are accessible to all persons.
- **Include** *http://www.stakes.fi/include*: The design of information and communication technology systems so that they are accessible to everybody including disabled and elderly people.
- **Tiresias** *http://www.tiresias.org*: Contains details of assistive technology devices for people who are blind or have low vision. Also contains reports on inclusive design of ICT systems.
- **Trace** *http://www.trace.wisc.edu*: The main American site relating to interfacing assistive devices to ICT systems.

B Information and Communication Technologies

- **Bluetooth** *http://www.bluetooth.com*: An open specification for wireless communication of data and voice.
- **DECT Forum** *http://www.dectweb.com/dectforum/*: Provides details of the DECT specification.
- **GSM Association** *http://www.gsmworld.com*: This association represents GSM operators.
- **ETSI HYPERLAN/2 standard:** *http://portal.etsi.org/bran/kta/Hiperlan/hiperlan2.asp*.
- **IEEE 802.11** *http://standards.ieee.org/db/status/index.shtml*: Provides details of the 802.11 wireless interface.
- **Mobile Data Association** *http://www.mda-mobiledata.org*: Aims to increase awareness of mobile data amongst users and their advisers.
- **Mobile Data Initiative** *http://www.gsmdata.com*: An industry alliance formed by some of the leading mobile telecommunication and information technology companies.
- **Mobile GPRS** *http://www.mobilegprs.com*: Details of General Packet Radio Service on mobile networks.
- **Mobile SMS** *http://www.mobilesms.com*: All about the text messaging Short Message Service on mobile phones.
- **Telecomms Technical Issues** *http://www.tapc.org.uk*: UK national resource on telecomms issues including a section on support for people with disabilities.
- **UMTS Forum** *http://www.umts-forum.org*: An international and independent body for creating a cross-industry consensus for the introduction and development of UMTS/IMT-2000.
- **WAP Forum** *http://www.wapforum.org*: The Wireless Application Protocol for wireless information and telephony services on digital mobile phones and other wireless terminals.
- **Wireless Data Forum** *http://www.wireless.org*: An organization dedicated to publicizing successful wireless data applications and customer communities.
- **3GPP** *http://www.3gpp.org*: The Third Generation Partnership Project is producing technical specifications for a 3rd generation mobile system based on evolved GSM core networks and UTRA radio access technologies.

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