

Designing Future technologies for people with disabilities in a developing country

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Abstract: Both the physical and virtual aspects of our current society are designed for able-bodied people. This means that very often people with disabilities are excluded from participation and faces barriers to living independently. This paper looks at how current urban environments in a developing country can be altered to include people with disabilities and how future urban environments should be designed to bring about an enabling environment. This is done through the use of Information and communication Technologies. Interviews and persona workshops that included people with disabilities were used to inform the design process. This resulted in scenarios that describe a future enabling environment in detail using specific disabilities and available technologies. The paper illustrates that this enabling environment can be implemented today with the right partnerships with government, academia and industry.

Keywords: Design scenarios; e-Inclusion, Ambient Assisted Living

1. Introduction

People with disabilities face many obstacles in their daily lives that prevent them from fully participating in society and from living independently. It is obvious that the modern world, as well as current design practices, do not accommodate people with restricted movement, an inability to lift or stand, or who have hearing, sight or cognitive limitations. This means that People with Disabilities are first excluded from mainstream society and given the rapid advancement of technology, face further separation. These groups represent a growing, but much neglected market. However, there are many Information and Communication Technologies (ICT) that can make a difference in their lives, increase their integration into society and that are commercially viable.

The growing elderly population in Europe has significantly increased the quantity of research aimed at addressing the needs of people with disabilities (PWD's), as many of the technologies aimed at the elderly, can also be applied to PWD's. In [1] an overview is given of the latest European ICT research trends in products and services aimed at people with disabilities. They show that with the advent of broadband, mobile technologies and ambient intelligence, the lives of PWD can be improved with services like location and navigation technologies that use GPS; automatic gesture recognition for sign language communication and control of technologies using limited movement; multimodal interaction to address multiple disabilities; and smart housing for more accessible living conditions.

In the USA, research in the disability domain is driven through the National Institute on Disability and Rehabilitation Research (NIDRR)[2]. They highlight research projects that include a personal digital assistant that provides task cueing and scheduling for people with cognitive disabilities; Sensory substitution for people with visual impairments where visual information is replaced with auditory or tactile technologies; and Augmentative and Alternative Communication devices for those with speech impairments.

Hence, a plethora of research into technologies that cater for varying disabilities are available. However, most of this research happens in the western world and therefore very little of these technologies or research is aimed at the conditions of PWD's in developing countries. Most of the technologies available to PWD's in developing countries are therefore expensive, difficult to repair as it has to be exported overseas and not localised (ie. Not available in local languages). There have been a host of "western world" ICT's and implementation ideas that have failed when applied in developing countries. In these cases the main reason for failure was that the context in which the technologies will be applied was not considered and therefore the solutions obtained did not match the needs, the organisational structures or the operational behaviours in developing countries [3]. Puri et. al [4] used three case studies of the implementation of a Health Information System (one each in India, Mozambique, South Africa) to show that even amongst developing countries, different socio-economic, cultural and political contexts can be found that will influence the implementation of the technologies.

It is clear that for success to be achieved, developing country-specific design patterns, methodologies and technologies are required that also speak to the marginalised groups in these countries. Some literature has emerged in the Information System design domain addressing design issues regarding developing countries ([7, 8]). The International Institute for Communication and Development (IICD) published a number of booklets [9] on the development of sustainable ICT's in developing countries. For them, context-specific design must go alongside broad-based technical and social capability development in users to prevent exclusion and ensure effective use of ICT's. After studying 40 projects in three different countries (Peru, Sri Lanka and Zimbabwe), Schilderman [7] suggests six ways in which development agencies can improve their grass-roots impact. These include looking at the demand-side of design, i.e. getting user participation and buy-in before the project starts; using inherent community based communication techniques (like community theatre, song-and-dance, local language etc.) and the use of key community informants to gain design specifications as well as widespread education about ICT's to the community. However there is little literature that addresses design practices in marginalised groups, while Schilderman further noted that there is a need for greater knowledge about the design successes in developing countries and that the lessons gained from case studies, "and particularly of its information components, should be documented better and shared widely."

This paper addresses the problem of designing a future enabling environment catering specifically for people with disabilities in an urban environment of a developing country, South Africa. The aim was to design technologies and prescribe illustrative case studies that show a future urban environment where people with disabilities are integrated into society through the assistance of appropriate ICT. In this paper, interviews and persona workshops are first used to provide insight and knowledge about a user population that has little experience in the use of ICT, and therefore difficulty in expressing their technological needs. This insight is used to form the basis for the design methodology. Furthermore, through the case studies, the paper shows that most of these technologies are available today and with the correct implementation strategies can be made available to people with disabilities. However this requires the correct support from government, academia and industry.

In the next section we give a brief overview of the objectives of the project. This leads to the method section which describes the interviews and the persona workshops. The scenarios obtained from the persona workshops are then discussed and the paper concluded in the final section.

2. Objectives

An **Enabling Environment** is an environment¹ (whether physical or virtual) that is designed or augmented in such a way where everybody, irrespective of disability or age, has equal participation and there are no barriers to their operation, integration and independence. This is especially important for people with disabilities, who on a daily basis face barriers that include access, navigation, mobility, health, communication, language, illiteracy, and marginalisation in society. The main goal of this project is to investigate how to identify and remove barriers in the environment and to use information and communications technology (ICT) to empower people with disabilities to live independently. This in turn will enable them to be an active part of society and the economy.

There are two major principles that are guiding the Enabling Environment research:

1. A general trend for new technology in the information society is towards Ambient computing [6] that is ubiquitous, unobtrusive, intelligent and adaptable. This means that technology must be able to integrate people, the built environment and technology; and adapt to the needs and requirements of ANY user.
2. The Disability domain is moving away from providing assistive technologies for a disability (although this is sometimes still required), to insisting that the society and environment change to allow their equal participation. Therefore technologies should be embedded in the environment without placing any additional constraints on the user.

Not much research is specifically focused on addressing the needs of multiple disabilities; however, the goal of an Enabling Environment is ingrained in the principles of Universal Access. The Universal Access approach [5] implies that all aspects of society and technology must be such that it can be accessed and used by anyone, at any time and in any place [6]. The problem is that many of the traditional approaches to answer this precept have followed a reactive paradigm. This means adaptations/alternatives for people with disabilities were only introduced after the design of the environment. Furthermore, these environments were originally designed for able-bodied people, where users who are disabled were only allowed access through assistive technologies introduced a posteriori. The drawbacks are that these adaptations will then only allow limited and low-quality access, with possible loss of functionality for the user in the environment [6].

Given these problems, a new approach called Design for All [5] has been advocated to answer the principles of Universal Access. Design for All says that environments must be constructed from its conception, design and release to accommodate all users without any modifications. Furthermore, current established environments must be adapted to accommodate for all users, therefore “fixing” the previously ill-designed environment and removing the associated barriers. Here the focus is not so much providing an assistive technology to aid in the disability of the user, but on “enabling” the environment. Thus providing solutions in the environment and society that caters to the user, while facilitating equal participation, access and use.

The difficulty this entails is in considering the needs of the broadest possible end-user population and the multidisciplinary approach it requires. This can however be addressed with distributed, intelligent and connected technologies that have the capability to be aware of user needs and adjust accordingly. These technologies must be present in everyday objects, where and when the user needs it.

¹ In this document the word environment will refer to both physical (ex. townsquare, buildings, room) as well as virtual (ex. ICT system, desktop, PDA) environments

3. Methodology

To address the problems listed in the previous section, the project team was asked to design a future urban environment that would be able to include people with disabilities. There were 2 main methods used within the first phase of this project:

1. *Understanding the user circumstances.* Through the use of social engineering approaches like random interviews in urban areas, the team attempted to understand the contextual circumstances of the users and their functional requirements within an urban environment.
2. *Understanding the user and their technological needs.* Persona-workshops focussing on specific disabilities were used to encourage the team to think from the perspective of the user. People with various disabilities were included in all of the discussions. The idea was to design interventions that is user-centric and comes from a disability perspective where the technology was design around the question: What can be done to remove the barriers that the user faced? This is different from asking: Which/What kind of technology will fulfil the user needs?

The project team consisted of 5 Researchers (2 Phd's, 3 Masters) with expertise in Ergonomics, Human Factors, Artificial Intelligence, Social Engineering and Hearing Impaired Disabilities. It further included 2 persons (1 Phd, 1 Masters) with architectural backgrounds; 2 Design experts both with Master Level degrees and a person with 10 years experience in Software Analysis.

The sections below discuss the details regarding the implementation of these two methods.

3.1 Interviews

For the purposes of this project, it was required to investigate an environment that will provide an understanding of the functional needs of people in an urban environment. It was decided to investigate Church Square (CS) in the city centre of the municipality of Tshwane, the capital of South Africa. Church square is a popular public town square used for a variety of purposes. It is a hub for many functions including commerce, education and recreation. It is surrounded by public buildings (ex. post office, tourist office and court house) as well as commercial institutions (banks and training centre), and is in close proximity to many public transport hubs (ex. bus stops, taxi ranks and Pretoria train station).

Two surveys were conducted with the purpose to interview people about their experience during their time at Church Square, including issues of navigation, accessibility and improvement. For each survey, interviewers were stationed at the four entrances of CS and they were instructed to randomly select passers-by and with agreement from the passers-by, ask them a pre-selected set of questions. In the first survey (06.09.2006) the following questions were asked: Who goes to Church Square (CS)?; Which transport do they use?; and Why do they go there? In the follow up survey (10.01.2007) the investigation involved finding out how people use the CS space, how they feel about navigating around CS and what are the physical and emotional barriers they experience. Observations, questionnaires, interviews and photographs were used to gather information. The demographic profile of participants was assessed according to age, type of disability, gender, occupation and language group. The information gathered from the interviews was then provided to the participants of the persona workshop to inform their design decisions. However the people who were interviewed did not participate in the persona workshops.

3.2 Persona Workshops

The Enabling Environments project team conducted 2 workshops where personas and scenarios were investigated. For a selected scenario a persona embodies a person with a specific identity – with his/her own name, age and personal details. Personas make something abstract more concrete, enabling the team to approach the problem (as explained through the scenario) by focussing on an individual and to find solutions for the specific individual. This is to gain a better understanding of the requirements and experience from a user perspective.

Each team had to develop a persona that is either an aged person, a blind person, a Deaf person, or a person using a wheelchair. The persona had to be specific, including the name, age and gender, a picture of each persona, disabilities and abilities, educational level, social background and any other personal details. Furthermore, people with relevant disabilities were included in each team to ensure an informative process. After the personas were developed the team was asked to describe a scenario for their persona. The scenario had to address the general activity of going to a bank in Church Square and incorporate the modes of transport used, the activities required and the difficulties experienced.

Each group then designed or conceptualized products, technological or architectural interventions to help each persona to accomplish his/her goals addressing the difficulties experienced. The assumption was made that the required technology building blocks is available. If possible, each group could design prototypes, high or low-tech, of their products and interventions.

The first persona, Rajendra Magadam, is a 30 year old male with retines pigmentosa. He was born with full sight and spent his first two school years at a mainstream school. At age nine he started to attend a school for the blind and gradually went blind until he was fully blind at twenty. His first language is English and he completed matric. He knows Braille, is trained as a telephone operator and has no PC skills. The scenario selected for Rajendra is withdrawing cash inside the bank in Church Square. In order to achieve his goal he will need to navigate, get into a taxi, walk to the bank, go into the bank and find the place to withdraw cash. This will lead to difficulties with hailing a taxi, embarking the correct taxi that goes to Church Square, disembarking at the right time, using an external ATM (since it is inaccessible), entering the bank with a dog, asking for directions (getting poor directions and instructions from others), trusting an unknown employee to withdraw cash for him and then finally getting back to his office.

The second persona, Busi de Beer, is a 26 year old female and is completely Deaf. She is illiterate, her first language is the South African Sign Language (SASL) and she has basic lip-reading skills. The scenario selected for Busi is getting foreign exchange from the bank in Church Square. In order to complete this task she will need to walk from home to the bus station, buy a bus ticket to go to Church Square, get off at Church Square, go to the bank and get foreign exchange, go shopping for clothes and luggage and relax in the park before going back home. This will lead to communication problems when buying a bus ticket, asking for the correct amount of foreign exchange and the currency that it should be in, as well as asking for the price of an item, with no price tag, when she goes shopping. Therefore she will require an interpreter. She also cannot count and therefore she has to rely on the shop cashier to tell her when she has given enough money.

The third persona, George, is a 46 year old male with a mobility impairment. He is a quadriplegic following a car accident at the age of 33 and therefore he is in a wheelchair and has limited movement of his hands. He can speak English and Afrikaans and has matric. He wants to go to the bank in Church Square to open a bank account. In order to achieve his goal he has to consult the bus timetable on the notice board, arrive 15 minutes early before departure, indicate to the bus driver that he wants to go to the bank in Church

Square and arrange pick-up. He will experience problems with the ease of access in and out of bus and the room inside the bus is inaccessible for wheelchairs. The bus driver needs to offload George and his wheelchair on the pavement and he will experience difficulties moving from the pavement to the road as there are no ramps in Church Square. Getting inside the bank causes a problem of accessibility, since the bank is an old building without ramps. The queuing in the bank is done in a zigzag formation that is too narrow for the wheel chair to fit in. The bank counter is too high to communicate and to reach to give/write a slip. Even the table for filling in a form is too low for a wheel chair.

The fourth persona, Ntane Mogale, is a 72 year old male and therefore an aged person. He had a recent hip operation, uses a walking stick, is partially sighted (uses glasses) and makes use of a hearing aid. His first language is Sesotho and he has completed grade 8 at school and is a former community leader. The scenario selected for Ntane is to deposit money at the bank in Church Square. In order to complete this task he has to interact with the bank manager, get refreshments and call home from a public telephone, get on and off the public bus and walk to the main intersection and use a taxi from there. He will experience environmental problems that include too many steps, no clear signage, a lack of information and an inability to recognising the bank. Communication problems will exist because of a language problem, technical terminology and new language or concepts.

3.3 Discussion on Interviews and Persona Workshops

There were a few limitations that were experienced during the interviews. Interviewers sometimes found it difficult to talk to interviewees about technical terms such as PDA or even the term accessible. This was mainly due to the lack of technical literacy as well as the fact that many ICT terms such as PDA do not always have an equivalent in other South African languages. Again this speaks to the need to educate users before implementation or even design. It was also difficult to engage possible interviewees as many respondents were just passing by and could not be interrupted or exited the square area before an interview could be agreed upon. This meant that the project team had to send different interview groups, at different times, to increase the number of interviewees and ensure that a diverse sample was attained.

The interviews only provided a small snapshot of the social element in defining enabling environments. However, the key aspect of the interviews from a design perspective was to include all the members of the project as interviewers. This was part of the “education” of the project team as their involvement gave them new insights into the needs, experiences and circumstances of people with disabilities, improving the design process.

The persona workshops benefited from the experience gained through the interviews, as the project team had a better understanding of the technical challenges of PWD’s as well as the environment within which technologies will be applied (i.e. Church Square) Furthermore, the inclusion of people with disabilities ensured that all three dimensions – people, environment and technology – was integrated into the design process. Although the project team assisted with the technical practicalities of the design, most of the ideas came from the PWD’s included in the team. This again shows that the users are a valuable asset within a design process. It is important to note that all of the PWD’s in the project team had either relevant education qualifications in ICT or had 3 or more years of experience in the ICT field.

As has been shown before ([10], [11]), user participation is vital in any design process. However, in developing countries it is important to consider the technical literacy, as well as the experience and educational levels of the users involved. Training and education in regards to ICT’s and their potential is often needed before users can be involved in the

design process of ICT systems. On the other hand project teams also require education in terms of the user needs and the application domain within which they are trying to implement technologies.

4. Summary of Possible Interventions

A possible intervention for a blind person is called the “Environounce”, which is an intelligent mobile information device with the capability to scan the environment, inform and guide the user as necessary. It will have the capability to scan the environment via wireless 2-way communication, reacting on object signals, city and building infrastructure with electronic recognition tags and picking up the closest object of interest. Possible examples where the scanning capability will be useful are a taxi announcing itself to the device; taxi driver being made aware of the blind person through device-taxi communication; bank location announces itself and indicates the location of the door; bank personnel notified and operation of escalators and lifts.

There were two possible solutions thought of to cater for the difficulties that a deaf person might face. The first is a hand-held “Sign language gesture recognition instrument” that can convert sign-language to spoken language and vice versa, while the second was a “Touch-screen” digital information table that can be used as a communication counter. The Sign language gesture recognition instrument is a hand-held device based on an alphabet communication board with pictures (specific to a service) with options to translate the pictures to Sign language or Text. The touch-screen counter is a similar device but installed as a bank/store counter and will allow the deaf person who only understands sign-language to communicate with the assistant behind the counter.

Most of the difficulties discussed for the person with mobility impairment had to do with transport and physical access. This can be easily rectified if adjustments are made to current transport services such as secure wheelchair inside public transport, sufficient space for a wheelchair, soft head rest at height of person in wheelchair, hydraulics drop down of the bus and ramp extension from below the bus at the door.

For the elderly person transport interventions can include the taxi-position detection system similar to that described for the blind person and environmental interventions can include identifiable “Visual” Reference Landmarks and having adjustable ramps as an alternative to stairs. A portable translator device (similar to the deaf person) can address communication problems. Devices can be used to assist with navigation and providing additional information.

More information regarding the specifics of the interventions can be found in the Appendix.

5. Discussion

The persona workshop showed that there are many obstacles and difficulties that people with disabilities experience during their daily activities. These obstacles are caused by the “able-bodied centred” design of current environments and the associated behaviour of society within these environments. Despite the many obstacles, they can all be categorised into four generic barriers similar to the categorization by the NIDRR [2]. These are:

Societal Attitude: Many of the problems that people with disabilities face is related to the attitude that other people, and therefore society has towards them. This comes from a lack of understanding of the circumstances of people with disabilities and how to appropriately assist them. Although this is not purely a technological issue, it does have an affect on the development approach of technologies for people with disabilities. Most of the time people with disabilities just want the information that is available to able-bodied people, and they

do not necessarily want to be assisted during each step towards completing a specific goal. The provision therefore of the relevant information at the right time and in a suitable manner has more of an impact than an assistive device.

Mobility and Wayfinding. This category includes physical access as well as the ease with which a person with disability can move around independently within an environment. Examples of the latter would be the difficulty that a blind person would experience walking on a crowded sidewalk, or an illiterate deaf person that has to walk with an interpreter when interacting with any external environment. Furthermore, it speaks to the need of a person to orient him or herself and then to navigate to a destination using an appropriate route. With all of the personas this was highlighted as a problem as illustrated with the aged person experiencing difficulties because of unfamiliar surroundings; signs and visual markers in a different language and unsuitable available routes.

Communication. All people have the need to communicate with others and to be able to express themselves in the manner or language which is most comfortable to them. Many types of disabilities experience barriers with regards to communication since communication can be visual, auditory, physical or cognitive.

Information. Access to information and the ability to generate and interpret information is a vital need in today's society. However, information is often available in a format that is inaccessible (ex. bus timetable only in small print, traffic lights only in visual format); input mechanisms are unsuitable (ex. difficulty of quadriplegic to use keyboard and mouse) or information is constructed in such a way that it is difficult to interpret (ex. new concepts/technology for an aged person).

Given the unknown domain of disability, initially it was thought that ICT solutions would be large-scale, require broad-based multi-faceted approaches and be difficult to implement. However, this paper shows that the needs of the user, as well as the categories within which ICT solutions should be focussed, can be streamlined. In essence, users want information about their environment and how to interact within this environment to feel safe and comfortable. This is therefore an ICT need that can be easily addressed with accessible technologies suited to the user's level of ICT experience.

Also, the specific challenges of technology implementation in a developing country must be taken into account, as enabling environment technologies will require action from multiple parties. Policies, regulations and initial infrastructure establishment (ex. location tags on public transport and the wireless area networks) will have to come from government. On the other hand researchers must investigate more efficient and optimal solutions suited for local circumstances; while industry must build the technologies and include them within future environments. As an example the project team is currently researching the potential implementation of an intelligent adaptable office room that is "enabled" for people with disabilities. This was done to focus and streamline research efforts into a specific environment and includes research into the social needs of PWD's in an office environment; Multiple Mobile sensor technology; Intelligent Context awareness and World Modelling; Artificial Intelligent reasoning and Overall system Software management. It is envisioned that these will provide the building blocks for future larger (ex. urban) enabling environments.

The persona workshop delivered specific scenarios that can be of assistance to designers of ICT technologies (see Appendix). The technologies suggested is similar to the current trends of Ambient Assisted Living in the European research domain, but is localised enough to provide technology designers a basis from which they can ensure that people with disabilities are considered in the initial design of future urban technologies. The needs of people with disabilities are similar throughout the world, but the scenarios listed show that the implementation of the technologies must be adjusted. Suitable, accessible

technologies require the understanding of local circumstances that include factors such as affordability, local languages and the level of ICT education of communities.

6. Conclusion

The paper shows that through the use of informative, user-centric design methodologies, ICT systems can be created that can ensure that people with disabilities are integrated in society. Specific scenarios are presented that shows the practical aspects of these designs and can be used by other designers as case studies. With the appropriate partnerships with government, academia and industry these technologies can be implemented today. However, implementation strategies must take into account the local circumstances of the user. In addition, any delay in implementation will increase the separation that people with disabilities experience in our current society. It is therefore important that the conditions of people with disabilities must be considered in current and future ICT design to ensure that all people have the freedom of choice to operate within society.

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APPENDIX

A. An Enabling Environment possible today or tomorrow?

This section provides two scenarios within which sample scripts for each disability persona mentioned in the paper are developed. The first scenario is a near future scenario describing interventions that can be implemented using today's technology. The second scenarios looks further ahead in the future and describes interventions that should be designed in order to attain a fully enabled environment.

A.1 Near Future Scenario

A.1.1 Background

In this appendix a few sample scripts are provided showcasing possible interventions that will aid people with disabilities within an urban environment. These interventions were designed based on the information gathered from the interviews and the persona workshops. One of the main assumptions that are made in the near future scenario is that all public spaces and landmarks are tagged with an electronic identification device (RFID) and that there is a wireless public area network that connects them. Information is stored electronically either locally at the specific public spot or at a central server connected to the network. Public transports are also tagged and have locally stored information and computing power that allows them to connect to a public area network. All of these networks and landmarks are capable of connecting to each other or a portable device carried by any user entering the public space. Also, for the near future scenario many of the translation services (ex. sign-language to speech, speech recognition, etc.) can not be done automatically and has to be done via a remote call centre as explained below.

People also have available to them mobile devices that can be wearable and act as intelligent information and communication tools. The devices have multi-modal communication abilities and can render information via audio, tactile (like vibrations), visually, etc, and can receive input via voice, menus, touching or any mode that the user prefers.

The generic barriers described in the paper cuts across all of the disabilities and assist in creating more focussed technology that once implemented, will alleviate difficulties and obstacles for more than one of the disabilities. Therefore the first case which relates to the blind person is described in detail so that an idea can be formed about the interventions in use. Subsequent cases that speak to the other three personas are much shorter as only the aspects of the technology that addresses their specific requirements are listed. This shows that the same technology can be implement in the environment and only with minor adaptations still solve the problems for a range of disabilities.

A.1.2 Blind person: Rajendra

Rajendra has a wearable (ex. around neck like necklace or arm like watch) mobile device and uses mostly the voice input (as well as pressing of buttons) and the audio and vibrating outputs. As Rajendra exits his office onto the street he indicates to the device that he is waiting for a taxi to Church Square via voice input. As all taxis are electronically tagged, the device scans all the beacons that it can pick up and alerts Rajendra (via light vibration or audio output) of an approaching taxi going to Church Square (CS). The driver is alerted by a device fixed in the taxi that there is a person waiting for a taxi to CS at the corner of Pretorius and Visser Street. The information about the location of the potential passenger was conveyed to the taxi-device from the user mobile device, which picked up the location via GPS and the public area network. On route the device informs Rajendra of his current position using GPS technology. As the taxi approaches the destination the device alerts Rajendra of the time to destination and to prepare to disembark. The taxi-device also alerts the driver to stop at destination.

After disembarking from taxi Rajendra requests his current position from the device (i.e. Press "orientation" button). The device detects the current position based on landmark RFID tags and informs Rajendra in a suitable manner: "You are on the corner of street X and Y, facing north in street X".

Rajendra indicates that he wants to go to the nearest bank ATM (Voice input). The device informs him of the position of the nearest ATM in relation to his current position "The nearest bank ATM is at the corner of streets X and Z next to shop A on street X and shopB on street Z, 100M north-west from your current position". If Rajendra prefers he can opt to have the information presented in another format or description: "The nearest bank ATM is 500 steps north-west from your current location."

Rajendra requests route navigation to his destination by pressing the "Navigation" button. The device informs Rajendra of the most accessible route to his destination based on his current position and taking into account all known obstacles: "Walk 20m north until you reach the corner of X and Z. Cross traffic light. Walk 23M west on Z. The ATM is on your right." Rajendra starts walking. As he approaches a landmark, the device informs him by vibrating. To get more information, Rajendra requests the name of the landmark: The device informs him of the landmark: "You have reached the corner of X and Z"

As Rajendra approaches a temporary obstacle (ex. roadwork that started that day), the device detects the obstacle (obstacle is indicated on an area database and has a RFID tag) and alerts Rajendra of the obstacle and how to navigate past it: "Beware, there is a temporary construction obstacle ahead on the sidewalk of street X. Keep right." Rajendra can at any time request an update on his orientation and route. The Device alerts Rajendra that he has reached his destination: "The bank ATM is directly on you right."

The ATM is Voice-enabled (can use headphone as well) to convey information and options. The Middle nr (nr 5) and action buttons (like "Cancel" and "Enter") are marked appropriately. Rajendra inserts his card into ATM and are able to complete transaction independently, because of voice-outputs and markings.

In the same way as above, the device now navigates Rajendra back to the taxi ranks and alerts him when the correct taxi arrives and alerts the taxi driver to stop at taxi rank.

A.1.3 Deaf Person: Busi

The same mobile device as described for the blind can be used, but this time it is built into a watch. Also the input is menu-based with pictures and logos (ex. Drop-down list with all the businesses in the area, and touch screen) and output is graphical, with maps, arrows and sign-language graphics. When person arrives at Church Square the local information, like maps, businesses in the area, etc., is downloaded to the device and used to orient and navigate Busi using sign-language video output.

The first option is for both the bus ticket office and the bank to have sign-language booths that are enabled with a video capturing, tracking and remote connectivity terminal. When Busi arrives at the "sign-language enabled" counter she starts signing her request. The video is relayed, via video-conferencing connectivity, to a sign-language interpreting service where the message is translated by a physical person to voice and relayed back to the assistant behind the counter. Anything the assistant speaks is in a similar way translated from voice to sign-language video and displayed on a screen in front of the counter. This assumes that there is a central interpreting service - physical persons like a call centre - available via which sign-language booths can connect.

The second option is for Busi to wear a communication device embedded in an item of clothing (ex. Belt/cap/shirt) that has video capture and tracking capabilities as well as remote connectivity capabilities. As she signs the video is relayed to a remote interpreting service that translates the message. Voice is then send back to the device that speaks out the message in the preferred language to the person Busi wants to communicate with. Busi also wears a mobile video display device (ex. in a watch) that records the voice from the other person, send it via connectivity capability to the remote interpreting service where message is translated into sign language. The sign language video is then displayed on the device.

A.1.4 Physical: George

The same mobile device as in the other scenarios can be used. The device can either be something like a cellphone, or built into George's wheelchair. The device knows which disability the user has and plans the most accessible route appropriate for the disability. For George, the device will show the route that has ramps, no stairs/curbs or any other inaccessible obstacles. Input in this case can be text-based with a cell phone keyboard or via a head-mounted pointer if George is incapable of using his hands.

All the public transport, as well as the height of counters, buildings and ATM's are physical accessible with ramps, wheelchair-sized widths and heights, even and properly maintained surfaces, and hydraulic extensions.

A.1.5 Aged: Ntane

A similar mobile device as in other scenarios can be used; however in each case a different functionality of the device is showcased. Ntane is not comfortable with technology and therefore might not regularly need one or own such a device. Ntane then first goes to the information kiosk which is easily recognisable, signed and indicated in all languages. Here he explains to them his goal for the day and he receives a user-friendly device that he can clip onto his walker and his profile including his abilities, needs and language, is entered into the device by an assistant.

The input is menu-based as in the case of the deaf and in the language of his choice while the output is voice-based and he can easily use it without any assistance. For navigation the device is aware that the person needs frequent rest-stops and therefore indicates this on the route-map. As Ntane walks, sign-posts via RFID tags are indicated on the map and he can choose that a specific sign is described or read in the language of choice.

In the bank he tries to communicate in Sotho, but no-one understands him. A bank worker then presses the translation service button on the device. The device records the Sotho dialogue, relays it to a translation service (similar to the sign-language interpreter call-centre) where a translator sends back the English dialogue, which is then voiced out by the device. Vice versa, the English is translated into Sotho and voiced out/displayed by the device. The last sentence can be repeated by the device.

When Ntane exits the bank, the streets and crowds are suddenly much busier than before. He gets disorientated and confused but he presses the clearly visible "HELP" button and the device connects him directly to an operator proficient in his language of choice. The operator receiving the call immediately has the profile and location of Ntane available on the terminal. This information is sent by the device to the operator terminal. The operator and Ntane communicates directly, and the operator can calm him down, give him instructions to help him out, as well as send relevant information and instructions directly to the device (ex. a new route plan to help person get to a bus station). Alternatively, the operator can alert an assistant at the information kiosk to come and help Ntane.

A.2 The Future Enabling Environment

A.2.1 Background

In this section there are three major conditions assumed to be true for the future scenario. In the future the environment which includes buildings, furniture, lifts, landmarks, virtual spaces, and so forth, will become intelligent and adaptable to the user. This means that not only are the environment equipped with computing power that allows them to become

aware of the user and the user profile, but it can adjust the physical or virtual space as well as the objects (ex. adjustable counters, ramps, information) to match the requirements of the specific user (ex a ramp lowering itself to allow a child in a small wheelchair to use it). Secondly, the devices will become smaller, more sophisticated and inconspicuous. This ensures that technology is ubiquitous, yet unobtrusive. Lastly, all operations/services that were dependent on human interventions, like the interpreter call-centre service, become automatic and built into the environment or user device. All of these speak about a world that is truly user-centric and includes everybody irrespective of ability, skill-level or experience with technology.

To showcase such a world, the scenarios above are briefly revisited and the changes that such a future environment will bring about are highlighted.

A.2.2 Blind

The device is small and clips onto the collar of Rajendra's shirt for instance. It orientates and navigates him as usual, but this time to the entrance of the bank. As Rajendra enters the bank, the bank "environment system" detects the profile of Rajendra through the device, and asks him what services he requires. Rajendra explains that he requires cashing a cheque. The environment directs him to the appropriate counter and adapts the floor to a tactile surface to guide him: "There is a queue of 3 persons, walk approximately 5 meters in a north-west direction until you reach the queue barrier. The floor has already been adapted for you into a tactile surface that you can feel with your cane and follow to the appropriate counter." Rajendra then follows the tactile surface until the environment (using the output of the device) tells him that he has reached the end of the queue: "You have reached the end of the queue. There are 3 persons ahead of you.", and later "You are first in the queue, the next teller is available, please follow tactile surface. Teller nr 2 is available 2 meters to your left.'

A.2.3 Deaf

In this case the device can be a fashionable pair of glasses (or cap). It has video capturing that can automatically recognise the sign-language and translate to voice, as well as unobtrusively display sign-language back to the user on the lens of the glasses. As Busi enters the bank, the environment recognises the profile of Busi and in sign-language (displayed on the lens) asks Busi "What services are required?" Busi signs that she wants some foreign exchange. The sign-language is automatically recognised by the environment and the device then signs to Busi where to go. Communication with the teller is done through the device. The device automatically translates Busi's sign-language into English for the teller, and vice versa, the teller's English is translated into sign language.

A.2.4 Physical

Again, as George approaches the entrance of the bank the environment recognises George's profile. The entrance immediately becomes wider so that he can pass through with the wheelchair and any stairs adjust into ramps. Again George is ask "What services are required?" and directed towards the correct counter. As George moves through the bank the furniture is adjusted to accommodate the wheelchair and the counter is automatically lowered to a comfortable level for him.

A.2.5 Aged

In the bank, any dialogue is automatically translated by the device in the language of choice. If Ntane has forgotten what he wanted to do, the "environment system" can request the information from the device and assist the person accordingly. When Ntane exits the bank and gets confused; the device will pick this up automatically (through heart sensor, facial emotion recognition) and attempt to calm Ntane or assist him. If this is not possible it will signal an assistant at the information kiosk to come and help.