Mobile Technology for People with Cognitive Disabilities and Their Caregivers – HCI Issues

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Abstract. Smart phone technology is evolving to become more open to application developers. This trend is opening the way to development of personalized assistive technologies, location-aware services, and enhanced person-to-person communications. This paper presents findings from an international workshop, with participants from industry, policy, education, and private organizations. Participants mapped future directions for exploiting technical opportunities, with a focus on people with cognitive disabilities. HCI issues that emerged as critical include profile-based configuration of user interfaces and functionality, support for spoken presentation of text content, support for viewing web content on devices with small screens, and support for remote assistance, so that users can get help when they get stuck. In addition to technical issues, key process and methodology issues were identified, including more inclusion of self-advocates in design development and user testing, and increased recognition of and support for the overall "value chain" throughout system deployment and use.

Keywords: mobile technology, persons with cognitive disabilities, caregivers, assistive technology.

1 Introduction

The 2008 Coleman Workshop on Mobile Technologies was held on October 15, 2008 in Boulder, Colorado to discuss near and long-term strategies for utilizing information technologies to improve choice, independence, and quality of life for those living with cognitive disabilities and their caregivers. The workshop was conducted under charterhouse rules, allowing all members to freely speak their minds without individual attribution. Participants from industry, policy, education, clinical care delivery and private organizations addressed both technical opportunities and process issues in improving assistive mobile technologies. In this paper, we summarize the discussions at the workshop to encourage interest in this topic and participation in the work of development that is needed.

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2 Recent Developments and Opportunities in Smart Phone Technologies

Mobile smart phones are evolving to become more open for development with applications of value to people with disabilities. In the past, mobile phones were sold with a fixed repertoire of functions. While these devices contained powerful microprocessors, users could not easily install new software. More recently, Apple's iPhone and many new smart phones running Windows Mobile, Symbian, PalmWebOS, or Java ME allow users to install any of a very wide range of applications. For example, many smart phones support text to speech applications that can be useful for people who have difficulty reading.

Conditions are still evolving with respect to control of the particular applications available to users. Apple limits installation of "native" iPhone applications, those that can access the full range of phone features, to those approved by Apple and made available through the iTunes system. Other manufacturers and service providers do not impose this kind of control, but they may require applications to be tested and registered in order to access some functions.

As of October 2008, the operating system software for Google's Android smart phone platform is "open source". This means that a community can freely make an extension or modification to the platform software code, and it can also make enhancements available to others. Nokia has announced plans to make the Symbian software open source as well.

These developments are potentially very important for people with disabilities. Due to the limited market size, the commercial industry rarely supplies assistive applications except as required by regulations such as Section 508 of the Rehabilitation Act, or Section 255 of the Telecommunications Act in the USA. Allowing end users to dynamically install applications makes it possible for and encourages user communities, students, and other volunteers to develop and distribute useful applications. Making the underlying software platforms open source enables further important developments, since interested communities can design and implement significant extensions to the platforms that provide useful support for people with disabilities.

3 Technical Opportunities

Workshop participants explored a variety of developments that have the potential to support a broad range of mobile products and services. These technical developments include: profile-based configuration of user interfaces and services, support for spoken presentations of information, cross-platform software support, and support for viewing web content on small screens.

3.1 Profile-Based Configuration of User Interfaces and Services

Current personalization approaches emphasize independently configuring a large number of potentially confusing interface settings, including preferences for sound, display, messaging, and single key commands (speed dial, mute, etc.). In contrast, a profile-based approach offers the potential for users to easily select a range of information

displays and services tailored to their needs and capabilities. Once one or more profiles have been configured, the user can set multiple parameters to appropriate values by simply selecting a profile.

If combined with available contextual information, such as day of week, time, and GPS location, a profile-based approach could offer the possibility to appropriately adjust or even change information modalities. For example, sound volume can be automatically turned up while traveling or switched to vibrate when at a doctor's office. If a user interface architecture is designed to support this tailoring, it could also promote the modular sharing of UI services across applications and smart phone platforms.

Profiles for smart phones could be specified using the same schema being developed for computers and based on the AccessForAll framework (http://dublincore.org/accessibilitywiki/AccessForAllFramework/). Such profiles can be stored online and delivered by an identity provider to any device a user is operating.

3.2 Support for Spoken Presentation of Information

An overwhelming volume of information, both on the Web and in the world, is provided in text format. People with cognitive disabilities often cannot read and require a different presentation of text content, including textual controls. Unless some option for modality shift and augmentation are provided, this can create a significant barrier to information access and comprehension.

Smart phones can be used as translation devices by allowing such information to be converted from text to speech. Translation is not limited to web-based information sources; Kurzweil text to speech reading technologies are now available in Nokia smart phones so that users can read signage as they navigate the world. As smart phones become more powerful, they offer the possibility to translate complex information into simpler, more comprehensible forms that are appropriate to an individual's abilities.

3.3 Cross-Platform Software Support

Today, an application developed for a particular phone will usually not work on another model. This means that the cost of supporting a diverse range of users, who have different phones, is generally high. Applications that do not use phone-specific features, such as a camera or GPS sensor, and do not require information storage on the phone, can be developed as web applications and run via web browsers in a phone-agnostic way. The technical limitations of web applications, however, rule out many applications that could be useful to people with cognitive disabilities.

The emerging HTML5 standard (http://dev.w3.org/html5/spec/Overview.html/) will change this situation, and implementations of some HTML5 features are now available in Google Gears (http://gears.google.com/) for select smart phones. HTML5 provides means for applications running in a browser to use phone features and store information on the phone, so that applications can run without being online. This development will be important for reducing the cost, and increasing the availability of many applications, including some of interest to people with cognitive disabilities.

3.4 Support for Viewing Web Content on Devices with Small Screens

The Web offers tremendous opportunities for "on-the-go, anywhere, anytime" information access and sharing, and especially for people with cognitive disabilities with limited attention or memory. While market pressure for small screens may creates difficulties for people with vision difficulties, adaptive techniques are also emerging [1] that can automatically tailor presentations to fit limited screen real estate. We need to develop these techniques, with additional attention to supporting navigation and controls.

A promising technology, already demonstrated for screen reader users, is predicting what part of a webpage is most likely of interest to a user, based on their interaction history [2]. For screen reader users this can save considerable time and effort, since it is difficult for these users to scan from the top of a page looking for the desired content. The same technique should be valuable for people who can see but who cannot read well, saving them the effort of reading irrelevant material while searching for what they need. It should be especially helpful on devices with small screens, on which only a small amount of content can be viewed at a time.

3.5 Support for Remote Assistance

One of the most significant opportunities for people with cognitive disabilities is the potential to leverage smart phones as a lifeline for increased independence, by linking them and their caregiver community network. If technologies can be developed to support unobtrusive and secure monitoring services between at-risk users and trusted caregivers, new opportunities for independence can be explored, while providing a robust safety net when mobile users need assistance. In order to make this a reality, smart phone technologies and services must be reliable, robust, secure, and have the ability to alert caregivers either when a mobile user requests help or the system detects an unusual anomaly, such as the user wandering off course, a person who is no longer near their smart phone, or a system failure.

Smart phones should also allow enable users to remotely get assistance in using the device itself when needed. On desktop machines, technologies like GoToMyPC (http://www.gotomypc.com/) allow a remote user to view and control one's machine, and this approach would be useful for many users with cognitive disabilities. Comparable tools should be provided for smart phone devices.

4 Process and Methodology Issues

Exploiting the opportunities just discussed, and others that will emerge, requires a *process* that will shape the underlying technology of smart phones in appropriate ways, and promote the development of applications that support people with cognitive disabilities. How can this process be promoted?

4.1 More Inclusion of Self-advocates in Design, Development, and User Testing

It has long been understood that development of effective computational tools and services requires deep understanding of the interests and needs of users. This

understanding cannot be developed without the participation of those users themselves. Unfortunately, software developers have been reluctant to include people with disabilities in activities like user focus groups and user test sessions [3]. Partly for this reason, it is too common that new devices and programs are developed with serious accessibility problems, as happened with the release of a popular smart phone [4] and a new web browser [5].

On the other hand, progress is being made. Shawn Henry [6] has published helpful information for those uncertain about how to be inclusive in user testing. The WebAnywhere project (http://webanywhere.cs.washington.edu/), developing a Web-based screen reader, has included blind people in each stage of development. Organizations like TEITAC (http://www.webaim.org/teitac/) and the Web Content Accessibility Guidelines working group (http://www.w3.org/TR/WCAG20/) have pushed for more representation of people with disabilities, including cognitive disabilities, in their work. The National Institute on Disability and Rehabilitation Research (http://www.rerc-act.org/) has funded device usage research programs explicitly designed to incorporate user focus groups, in vivo usage trials, and post-usage feedback from both users and caregivers.

This progress has to come for application development for smart phones too. In grasping the opportunities provided by increased openness, we have to develop organizations and work processes that include self-advocates as participants throughout the design, development, and testing process. Partnerships with national and local self-advocate organizations must be forged. Technology like York University's VU-Lab (http://www.vulab.ca/), that allows user testing to be performed remotely, may have a valuable role to play in enabling participation by a geographically scattered user community.

4.2 Increased Recognition and Support for the Overall "Value Chain"

Successful use of assistive technology (AT), when it occurs, is the culmination of a long chain of events, with many participants. For a person with a cognitive disability to become aware of appropriate technology, caregivers, advisers, and support staff usually have to be aware of it too. Choice of an appropriate device or application also requires knowledgeable assistance in nearly all cases, as does configuring a device or application once it is acquired. Often, training and follow-up adjustments are necessary since people with cognitive disabilities often cannot tailor a smart phone to suit their own needs. Further follow-up is often needed during long-term use, if that is achieved, since user needs and capabilities change over time.

For new technology to be successfully applied, all of the participants in this long value chain need to know about the technology and understand their roles in the chain. Clearly, these requirements go far beyond simply developing a "valuable" technology in the research lab, or even creating a product from it that can be made and delivered economically. Rather, the effort has to include substantial outreach and education to prepare a large supporting cast. This is a challenge to traditional models of R&D and funding, requiring new development models and processes.

4.3 Open Source Opportunities

The open source model of design and development provides considerable potential in creating better AT in both hardware and software. In this model, a community of developers works collaboratively to develop or enhance software tools.

Since these communities can be formed by anyone, and can be open to new participants, potentially anyone can contribute knowledge or resources to improving a product. In particular, a community of people with needs that are important to them can organize to produce software, without requiring the involvement of a commercial organization or research lab.

The open source model also allows persons living with cognitive disabilities, caregivers, and advocates to more directly provide input and feedback into the design and development process. This allows for software and hardware that is more attuned to the actual needs of the end users.

Once developed, open source software can be adapted by anyone with the desire and means to do it as needs arise. If someone wants a program to run on a different device, for example, they are free to adapt it. Because the same program is being adapted for the new device, rather than a new program being developed, a useful application may be made available on new devices as they appear, taking advantage of lower cost or improved performance.

This happy picture may not always be realized. It may be too difficult to create a program for a given purpose, or too hard to adapt it to a new device. Many successful open source projects receive substantial investment of paid work from corporate sponsors. Communities of people with cognitive disabilities, and those who support them, may not command these resources.

4.4 Education

Developing software for people with cognitive disabilities, or other disabilities, is largely neglected in current computing curricula. Thus, when students become professional developers they seldom have relevant skills or even awareness. But this problem can and should be addressed.

Student Projects. Many computer science curricula include substantial student projects, often with clients outside the university, as a way of introducing students to development "in the real world". Since faculty often have to work hard to identify interesting project opportunities, connecting these project courses with software needs in AT offers a substantial benefit on both sides.

One project approach is to consider how senior projects and capstone courses can be structured to focus on long-term projects that incorporate accessibility needs. Using this approach, the focus is not how to manage a single student group working on a project over a long period of time, but instead how to create course focus on a long-term project that rotates through several groups of students. This would also allow students to develop and extend an existing code base rather than developing new code from scratch.

Open source software, as described earlier, also has advantages in this connection, because students have free access to the software they need to work with, and the

open source project will have ways to evaluate and adopt student contributions. A thorny problem with student projects is long-term maintenance. Software always needs work over time to fix defects as they are found, to adapt to new devices, and to address new user needs. Student projects cannot meet these needs. Framing student projects within established open source communities would make it possible to take advantage of what the students can contribute, while relying on the larger community to meet the long-term needs.

Similarly, students working on a project cannot provide ongoing user support, training, and the like, including the needs identified in our discussion of the value chain. Here, too, framing student projects within a larger community can solve the problem.

Courses. Material on accessibility, including relevant standards, should be included in courses in human-computer interaction (HCI) in computer science curricula. Other technology and engineering courses covering diverse topics such as software engineering, universal design, pervasive and ubiquitous computing, and hardware design should likewise include topics concerning design standards and accessibility needs of people with disabilities. Information School programs, which have emerged at many universities in the last several years, should also include these topics in their curricula. Likewise, courses in the social systems, communications, and cognitive sciences also have strong reasons to include discussions of cognitive and physical disabilities and opportunities for interdisciplinary project collaborations should be broadly explored and encouraged.

4.5 Integration with the Raising the Floor Initiative

Grasping the opportunities described here will require large-scale cooperation. An organization is taking shape that promises to provide an effective framework for this, the Raising the Floor initiative (http://www.raisingthefloor.net/), led by Gregg Vanderheiden of the University of Wisconsin and Jim Fruchterman of Benetech. The central aim of Raising the Floor (RTF) is building essential AT into the basic information infrastructure we all use. RTF will not only make AT available to all who need it, but will also provide a higher level platform for AT than now exists, supporting enhanced applications developed by commercial AT providers, as well as by other developers.

Because of the critical role of the Web in our information infrastructure, web accessibility is the initial focus of RTF. But trends show that Web access from mobile devices is rapidly increasing, and mobile devices represent a larger share of our infrastructure. In response, RTF will seek to promote the availability of quality AT on mobile platforms as well as in traditional browsers.

As discussed earlier, web technology is rapidly changing and implementations of HTML5, like Google Gears, are starting to appear. This technology will further blur the boundaries separating mobile applications from traditional desktop applications. For example, it will be possible to automatically download and store data and applications on the smart phone when the device is not being used, just as is routine for desktop applications.

For AT applications, this attractive scenario requires that basic AT functionality, such as text to speech conversion, be available in any browser, in a uniform way. Once this is accomplished, applications like reading aids for people who can see but cannot read well, can be developed and provided at low cost, by commercial or non-commercial entities. This is a good example of the promise of the RTF initiative.

4.6 Standards and Regulation

With today's interconnected technologies, standardization is essential to progress. Operation of the World Wide Web depends entirely on the use of standard protocols; without these the whole fabric of communication that it supports would be impossible. As already mentioned, HTML5, which holds great promise for helping meet the goals outlined here, is an emerging standard of this kind.

Experience has shown that there is sometimes a need for regulation, as well as standardization, where access to technology for users with disabilities is concerned. One example is hearing aid compatibility, where most vendors have welcomed regulations to ensure smart phones are available that can be used by hearing aid users. Regulations mean that all vendors share the cost of serving this public purpose, and that vendors who make the needed investment are not thereby put at a competitive disadvantage. Regrettably, a popular smart phone that is not hearing aid compatible represents a regulatory failure in this respect, exploiting a loophole intended to exempt small industry participants [7].

The workshop participants agreed that regulation should be minimized. But what will a workable minimum represent? In the USA, current regulations do not require that most websites comply with accessibility guidelines, or, more accurately, court decisions have not made clear how existing law, in particular the Americans with Disabilities Act [8], will or will not apply to the Web. These matters may affect our ability to provide good access to web content on smart phones, as well as via more familiar browsers.

The Raising the Floor initiative will provide a useful setting for deliberation, and cooperative action, with respect to regulation. It may emerge that meeting the goals of RTF will require that smart phones meet some technical standards, in more or less the same way that hearing aid compatibility imposes technical requirements. Or this may not happen. Participants in RTF will be in a good position to identify and define such needs, should they emerge, and help frame appropriate regulations in response.

5 Expanded Opportunities, Collaborations, and Participatory Design

The workshop suggests the value of increased collaboration across discipline, organizational, and national boundaries in addressing these opportunities. The participants represented a wide variety of organizations, including academic, clinical, commercial, for profit and non-profit. A roadmap for progress emerged from the exchange among

technologists, who have a sense of that can be done; clinicians and others knowledgeable about people with cognitive disabilities, and people with long experience in the promotion of accessibility, including the realm of regulation and standards. Notably, there is great potential for sharing technology across efforts to support people with different kinds of disabilities.

The workshop would have been even more fruitful had we had participation by self-advocates (one self-advocate planned to attend but had to cancel at the last moment). As mentioned earlier, such participation should be a priority in these efforts.

Broader international participation will also be helpful. Attendance at the workshop shows cooperation in North America, as well as involvement of companies that operate on a global level. Even in its early days, the Raising the Floor initiative has participation from eight countries on three continents. Mobile technology is a global system, and work to make it more useful to people with cognitive disabilities will be a global effort.

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