Information Technology and Universal Design: An Agenda for Accessible Technology

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Abstract: Developments in information technology underscore the need for greater awareness, facilitation of universal design, and a focus on nontechnological barriers to implementing technology. The author presents his views on the current status of accessible technology, where the most significant barriers remain, and what may be done to address them.

Universal design (UD) was defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" by its inventor, the late Ron Mace (quoted in Center for Universal Design, 1997). The concept first emerged in architecture, but has expanded to the entire designed environment, including computers, telephones, and information systems of all types. UD makes sense from two important perspectives. For consumers, it means that more of the products and environments they encounter will be accessible immediately, without the need for any special accommodations or assistive technology (AT)—defined by the Technology-Related Assistance to Individuals with Disabilities Act of 1988 as "any item, piece of equipment, or system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities." In contrast to AT, UD's intended market is all people, whether or not they have disabilities. In fact, UD can be seen as a response to a principal weakness of AT: the fact that because of high prices and scarce information, AT reaches only a small fraction of its intended users.

Many AT experts recognize that UD offers an alternate path to accessible products or services, defined here as those that have features that enable a person with a disability to use the product or service, whether by itself or in conjunction with assistive technology. An *accessible mainstream product* is one that was not primarily designed to solve an accessibility barrier but that does so nevertheless. So *accessible technology* could be considered to be (roughly) the sum of accessible mainstream technologies and ATs. For companies, UD means a larger potential market because there are more successful users, many of whom are not disabled but may have found another product inconvenient or uncomfortable to use.

In architecture, UD may suggest a ramp in addition to steps leading into a building. How does UD apply to electronic products? Consider the design implications of a com-

puter. If the keyboard—the computer's entry point—corresponds to a building's steps, then there must be another way to provide input: speech recognition, perhaps. Just as a ramp is useful to many people who do not use wheelchairs, speech recognition is useful to people with or without disabilities. This is especially true if the design offers another choice, not only one way to command the system. More options mean more ways to succeed. Thus, universally designed information products offer users many input and output technologies, allowing each user to select and operate them in the most usable and convenient manner.

Looked at this way, some accessibility problems become easier to solve by offering more choices to the user, simply because some of the choices may be relevant to the user's disability. For example, changes in screen resolution, fonts, or colors may address the needs of a user with low vision, and volume control may suit a person who is hard-of-hearing.

To those who first attend an accessibility conference, it may seem that all the accessibility problems have been solved, either by AT or by UD. At these conferences, row upon row of products announce their ability to sweep away barriers to the use of information technology. Almost every day, a mainstream company releases a new, more accessible version of a product. But to those who have been up and down the roller coaster of expectations of accessibility, it is clear that technology itself is not the main problem. Between accessible mainstream products that are universally designed and the wealth of AT solutions, we are not confronted by purely technological barriers. Most of the barriers are informational and organizational. This article is concerned with these nontechnical barriers, which are both less exciting and more resistant than any technical ones.

Examining nontechnical barriers

Nontechnical barriers can be categorized as informational, organizational, or both.

Information

Few people know enough about accessible technology to solve their own problems or those of their family members, employees, or clients. Beyond the truly tech-savvy leadership circle, there is a real shortage of expertise at the service level. This scarcity is made worse by the fact that few people with disabilities know where to go to find experts. Furthermore, many people with disabilities do not recognize that they have an access problem or believe that they can find a solution to it if they know that they have one. Too many people, unfortunately, give up on the goal of integration because of pessimism and the lack of awareness.

Organization

Then there are organizational barriers. Large institutions, like companies and public agencies, may have many internal departments, each with its own skills, agenda, and role to play in decision making. Coordinating across these departments is often complex and difficult. Companies that should be responding to this potential market do not, often because their engineering departments are worried about cost, their legal departments have not completed their regulatory analyses, and the marketers do not believe in the projected return on investment. Studies of the adoption of UD have pointed to these organizational barriers as key (see Tobias, 1995; U.S. Access Board, 1999; Vanderheiden, Vanderheiden, & Tobias, 2000).

In addition, public agencies that serve people with disabilities cannot efficiently allocate their resources to address the most important problems. There is an overall shortage of funds to provide suitable evaluation and support services, as well as to pay for the correct technologies.

Examples of barriers

"Needle in a haystack" barrier. This purely informational problem arises not because of a scarcity of information but, rather, because of an overabundance of it. In the world of mainstream products, marketing hype is king. Each company strives to create a competitive advantage by trumpeting its newest breakthrough products and features. People have been conditioned to compare products by counting features, so that they automatically consider the product with more features to be better. Packaging, advertising, and the little training given to salespeople all emphasize the number of features, using complex and nonstandard terms, and pay little attention to accessibility and usability. For example, a study by the U.S. Access Board (1999) found that although an audible "low battery" indicator provides blind users of cell phones with important information, and many cell phones have this feature, the sales staff in typical wireless retail stores could not confirm its availability and were not willing to open a new box and search the user's manual.

"So close" barrier. This category consists of mainstream products that have all the components needed for accessibility but do not have them arranged quite right. One example is a telephone answering machine with a remote message-retrieval function. One can call into the machine from out of town and enter a pass code for security. The machine then announces how many messages are stored and when they came in, from what phone numbers, and so forth. The user can choose which messages to play, save, or delete and can hear the menu choices through the answering machine's digitized speech. But there is no access to the same interface if one stands in front of the answering machine. The user must be able to read the small LCD (liquid crystal display) on top of the answering machine. If someone had reviewed the product interface for accessibility, he or she might have suggested a mode that would work for blind consumers on the basis of the remote retrieval interface. The manufacturer probably would have accepted the suggestion at that time. In fact, once this barrier was pointed out to the manufacturer of a particular answering machine, the next model in the same price category did have a digitized speech interface. So this barrier is both an informational and an organizational one.

The next section explores a useful method of analyzing the accessibility of products. It is notable that examining a product for accessibility yields information that is useful to both designers and consumers. This coincidence makes "product accessibility audits" valuable tools for training.

Examining products

This section begins with a few simple concepts about products and users:

1. Users want to perform certain tasks to achieve their objectives. One example of a task may be "check e-mail."
2. Products perform certain functions that are consistent with and sufficient for the tasks that users have in mind. Here, an example is "determine if there is a network connection." Other functions

would have to follow, such as "establish a network connection if there is not one."

3. Users interact with products through features of the interface. They do not get below the surface of most products. In this example, the task would be to "activate checking for e-mail by clicking on the correct on-screen button or entering the correct keystroke command."

To analyze products for accessibility, the products can first be divided into their natural functional categories, such as wireless phones, spreadsheet programs, and ATMs. If only products that are in common use are considered, there are just a few dozen such categories. The Access Board's (1999) *Market Monitoring Report* showed only 16 categories of telecommunications devices: auditory accessory (amplifier, headset), analog wireless telephone, call-control accessory (caller ID, message-waiting indicator, speed dialer), central office switch or adjunct (including software), cordless telephone, environmental control for telephony, fax machine, Internet telephony device, network accessory (modem and control software, network adapter, and the like), PBX or key system, ring accessory (amplifier, light signaler), telephone answering machine, TTY and equivalent, videotelephone, wireless voice phone, and wireless text device.

Similar categorization can be performed on computing hardware (for example, desktop, laptop, personal digital assistant, server), software (for example, word processor, spreadsheet, database, e-mail client, browser), and so forth. The Access Board's (1999) Section 508 standards refer to only six categories of products. Clearly, any categorization scheme has drawbacks. The purpose of this particular categorization is to provide a framework for understanding the purposes for which people are using information technologies.

People use products through the products' interface features. Therefore, a second step in analyzing products is by the features they have, such as a keyboard, audio jack, and small LCD. There are only a few dozen such categories of features. For any given person, only some of the features will pose barriers. This approach provides a framework for understanding where accommodations and universal design fit into how products operate.

Taken together, product-category and product-feature information can neatly pinpoint the origins of inaccessibility and accessibility. For example, consider the LCD display of a wireless phone. For a blind user, this feature is a barrier (for a deaf user, however, the same LCD can be an accessibility feature, providing information that is otherwise only available auditorially), but there are some wireless phones with redundant audible output. Many models can be programmed to ring differently when they receive calls from certain numbers, and some can announce the digits of an incoming call. Although this is not complete access, it may be sufficient for a particular consumer. One can imagine a way to display information on products that is suitable for consumers who are looking for the features they need in the products they want. This method of analysis has proved useful in training corporate designers and marketers as well.

Current trends in products

This section explores some of the current technologies and their implications for accessibility, both positive and negative.

Mainstream products

There have been rapid advances in the accessibility of products since 2002, in both

mainstream products and AT products. In most product categories, there are now accessible models and models that are more compatible with ATs like screen magnifiers and screen readers. Not only are these products available in the market, they are being purchased and used more frequently. For example, a few years ago, talking ATMs were found only in exhibits at technical conferences. Now more than 7,000, from companies like Diebold, Triton, and NCR, have been installed, and another 3,000 are scheduled (personal communication from Lainey Feingold, attorney who has negotiated accessible ATM cases, 2003). The banks and advocates have discovered that just installing talking ATMs is not enough because usage continues to be lower than anticipated. The customers who are intended to benefit from the new ATMs are not aware of their existence or locations. To overcome this awareness or informational barrier will take continual efforts by industry leaders and advocates.

Speech technology, in general, is becoming more common. Just as anticipated, the additional cost of adding speech to consumer electronics has declined. For example, talking caller ID is now available in Panasonic cordless phones that cost less than $50. The first single-chip speech synthesis package that is designed for mobile electronics has just been released. It will sell for about $10 in volume, further lowering the cost of adding speech to electronic products. Several companies, both mainstream and AT, are offering talking GPS (Global Positioning System) systems that can tell you your location by referencing satellite data and a digital map. Mainstream talking GPS products include the Magellan 750M, Garmin StreetPilot III Deluxe, and Pharos Pocket Navigator (an attachment for pocket PC devices). AT versions of similar products are Atlas and GPS-Talk, from the Sendero Group; BrailleNote GPS, from Pulsedata; and the Victor Trekker, from VisuAide.

Software-based speech synthesis, which is already available for some models of wireless phones, has the potential to reduce the inaccessibility of cell phones with deep, complex menus on displays that require good vision. Some cell phones also have a "zoom" display feature, which enlarges the text or icons on the screen. Many phones now have audible warning tones for low battery or signal strength, and some have different ring tones for different callers. Unfortunately, information about which models have these features is not easy to find. These features are not "exciting" enough to be publicized on the packaging or in advertisements. By the time that consumer advocates and brokers of information on accessibility find out about them, the models may have changed.

The competition in the operating-system market continues to be hot, and all competitors are using accessibility as a feature, partly because of the provisions in Section 508 of the Rehabilitation Act, revised in 1998. Section 508 requires federal departments and agencies to purchase accessible information technology. Without some built-in accessibility features (for example, StickyKeys, which allows users to press keys one at a time instead of all together; high-contrast display settings; and screen flashes that accompany system beeps), no operating system can be expected to be successful in the federal market.

Windows, Linux, and Macintosh all have some accessibility features. Microsoft continues to add built-in accessibility features to Windows. All the most

recent versions include basic speech and magnification functionality and a wizard that helps the user set up his or her machine and find the necessary AT. The Microsoft/enable web site (see Microsoft Accessibility Technology for Everyone, 2003) provides excellent structured information about the accessibility and compatibility of Windows. The Apple Macintosh, which had some severe barriers in its early releases of MacOS X, has now gathered some accessibility steam. The latest version as of this writing, 10.2 ("Jaguar"), has improved keyboard navigation and a screen magnifier, but there is still no screen reader, by Apple or a third party.

Linux is the open-source operating system that is gaining ground as a server and on desktops. Its advantage is that it is highly flexible and modular. Linux users can add applications and utilities from hundreds of sources. There are hundreds of accessibility programs and tools. Unfortunately, the open-source environment also has its weakness. Since no one company owns Linux, no one has ultimate responsibility for accessibility. End users without access to tech-support gurus may not find what they need or be able to install and maintain it. This is another example of an informational barrier: accessible technology without adequate implementation support for accessibility.

AT

AT companies have forged ahead as well. Speech technology-based accommodations have moved from computer-only products to encompass several categories of products. There is an accessible (albeit expensive) personal digital assistant that offers mobile access to e-mail, word processing, spreadsheets, and contact management via speech technologies: the PAC Mate by Freedom Scientific, which unites JAWS with Microsoft PocketPC.

Some complain about the high price of advanced AT products, especially when funding is so inadequate. They compare the low cost of an off-the-shelf computer with the high cost of a screen reader, for example, which may cost more than a computer. It is important to remember that AT firms provide more than boxes of silicon. They are working uphill against the informational and organizational barriers. If a company must send a representative to dozens of meetings and conferences each month to get the word out about its products and then process the paperwork from dozens of bureaucratic funding sources, the staff time can be paid for only by the revenue from sales. The high price of AT products is quantified evidence that nontechnological barriers are the principal roadblock to a more accessible society.

A whole new category of accessibility services is arising: network-based accommodations—that is, services that live on a network of some sort and are accessed by users without special equipment. One example is a service that translates text into speech. Many of the major e-mail servers can do so or can be fitted with utilities to do so. Instead of using the computer's screen reader, one uses the network's synthesizer and accesses the content by telephone. This service is driven by the needs of mainstream mobile users to stay connected at all times; users who are visually impaired gain the same advantage from it, and at mainstream prices. Several phone-based web-browsing services are available, not the least of which is AOLbyPhone. For an additional $5 per month, AOL subscribers can receive their e-mail, browse to favorite sites, and even place calls to businesses

they have located, all through AOL. There are several advantages of network-based accommodations: There is no capital cost for the user, the accommodations are "portable," and they can be upgraded and maintained easily.

New technologies

New products or platforms continue to evolve, and one can never afford to stop scanning them for possible barriers. We all know well that accessibility is a lot easier to build into a product than it is to retrofit later.

Web technologies continue to be especially troublesome. They emerge and evolve at such a rapid pace that their inaccessibility does not become apparent until they are found on almost every site. Web development is so highly distributed that it is impossible to reach all those who control contents of sites and platforms—another example of organizational barriers.

A new focus on virtual-reality techniques promises to simplify the retrieval of information on computers, as well as to transform education and training. Some courses are already offered that use a three-dimensional display model of, for example, the components of an engine. The students manipulate the objects by mouse until they are oriented properly and assemble them on the screen. These interfaces, obviously profoundly visual, threaten to exclude users who are visually impaired. Users of screen readers cannot be happy anticipating environments that require navigation up, down, left, right, forward, and backward.

On the positive side, some research is being conducted that promises to keep screen readers compatible with fast-moving operating systems. Mainstream and AT companies are working to develop an accessibility application programming interface (API). APIs are the specifications for two different technologies to exchange information in a program. An accessibility API would standardize how AT and the operating system talk to each other. Having this API would allow AT products to work with new operating systems as soon as they come out and may attract new AT products by reducing the research necessary to begin to develop these products.

In the wireless world, a new model is taking hold. Instead of hard-wired products with manufacturer-determined functions, new cell phones have an open programming architecture. They are just like computers; you can load them with whatever software you want. Instead of a disk drive, they load software from the wireless network. Right now, most of the software is games and top-40 ring tones. But soon there may be downloadable software that will eliminate the need for the display because the telephone will speak out all the functions.

"Just-in-time accommodations" are also being developed. Imagine an ATM that takes information from the user's card and immediately downloads the exact interface preferred by the user. Some banks have already implemented features that allow users of ATMs to choose the languages that want to work in; there is no technical reason why a large-print or talking interface could not be similarly treated.

Another approach to AT is the "single interface device." In this model, a person would have one small device through which he or she would communicate with the entire technological environment: elevators, ATMs, vending machines, and so forth. The device, called a "universal remote console" (see International Committee for Informa-

tion Technology Standards, 2002) or "accessor" (see Newman, 2002), would contain the user interface, with input and output tailored to the user's exact specifications, and all the standard data-communication protocols in use, such as infrared, RF, and Bluetooth. The interface device would negotiate an appropriate and secure link with the environment and act as a translator, expediting whatever function the user wanted to perform.

Law and policy

It would be great if the market alone were responsible for all the accessibility improvements that have been made. But no one can deny the powerful motivation provided by laws and regulations on accessibility. Foremost among these laws in the past few years has been Section 508 of the Rehabilitation Act. This law, passed in 1986 but strengthened in 1998, requires federal agencies to purchase accessible electronic and information technologies. Companies that did not want to jeopardize their sales to the $45 billion federal market (see Office of Management and Budget, 2002) have been scrambling to understand and implement the accessibility and compatibility features required under Section 508. The same products, of course, are offered to the public at large, so the effective use of federal market leverage has improved accessibility for all.

Although not all agencies have been equally committed to implementing Section 508, the federal government as a whole has shown significant progress. Updated purchasing procedures, formal ways of sharing information about accessible products, training of staff and contractors, and ongoing meetings of Section 508 coordinators have contributed to a higher priority for accessibility in how the federal government works, both for employees and members of the public. While not all problems have been addressed, there is a sense of growing momentum and a growth in the resources available to federal employees and members of the public who need access to government information technology.

Unfortunately, many believe that the same cannot be said for Section 255, the portion of the 1996 Telecommunications Act that requires telecommunications manufacturers and service providers to make sure that all their products and services are accessible. The enforcement of Section 255 is based largely on consumers' complaints, with the Federal Communications Commission (FCC) playing the role of arbitrator in resolving problems between customers and companies. Although there have been hundreds of contacts with the FCC, only recently was the first formal complaint filed (by Bonnie O'Day, a blind consumer who is a member of the American Council of the Blind and a noted researcher and advocate for people with disabilities; see Spiegel & McDiarmid, 2003) about the inaccessibility of the menus of a wireless phone. Perhaps this complaint will spark others. In the meantime, while some companies have shown dedication and resourcefulness, others have made only halfhearted efforts or ignored accessibility entirely.

At the state level, there has been more progress. Almost all states have taken some action to guarantee accessibility in state-supported information technology. Some of these actions are only policy statements, but almost half the states have adopted more stringent measures, such as laws that apply the Section 508 standards or their equivalents to all state purchases and programs.

These state initiatives have focused on web accessibility, procurement processes, and software application development. The Information Technology Technical Assistance and Training Center (ITTATC), funded by the National Institute on Disability and Rehabilitation Research and housed at the Georgia Institute of Technology in Atlanta, offers a useful compendium of state accessibility laws and policies (see ITTATC, 2003).

Conclusion

In this article, I have explored a number of key technologies whose functions are at the heart of employment, education, and communication. We in the field of visual impairment know that without access to these products and services, people with disabilities will not be able to participate in society. Technological trends are exciting because they offer more potential access than ever before through speech and customized interfaces, at a lower cost and with greater availability. We are right to become enthusiastic about their potential.

However, for every promising new technology, there are dozens of concerns about how to reach the millions of disconnected users with disabilities (especially older people), how to mobilize companies to avoid designing barriers into their products and services, how to demonstrate the value of accessible technology as a liberating force for personal development and productivity, how to pay for needed AT products, how to keep the policy world's regulations fresh and relevant, and how to keep up with the accelerating pace of technological evolution.

The key to addressing all these problems lies in the development and nurturance of a cadre of technologically sophisticated professionals who can communicate with multiple audiences. These professionals must be able to absorb new technologies, identify their implications for accessibility, and provide guidance to engineers and designers. At the same time, they must have the business background to be able to explain the motivations of the disability market and the need for companies to develop accessibility programs. They must also have the public-sector expertise necessary to tailor more creative and effective policy instruments. And above all, they must be focused on communicating with consumers about their technological options: why technology is important, how to think about their needs, and how to improve their effectiveness when they are in the market for new gadgets. We all know some people who fit these descriptions, but there are too few of them.

If we can resolve the nontechnological issues as well as we address the technological ones, we can look forward to a Golden Age of Accessibility. If we continue to focus on technology alone and ignore its context, we will serve few and disappoint many. Only if our understanding of the realities of the market and our commitment to serve consumers match our technological sophistication can we offer a balanced program that will accelerate the massive inclusion of people with disabilities into the empowering world of information technology.

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