Federated Databases and Supported Decision Making

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Abstract. Currently, information required to make informed choices of appropriate assistive technology products is scattered among broad, general-purpose databases and narrow, focused databases. The vocabulary used to describe features has not been standardized, and can be very hard to interpret by end-users of assistive technology. The described project will create a federated Unified Listing of assistive technologies for information and communication technologies, and develop a Shopping Aid, using information provided by the individual to filter products and services from the Unified Listing to those that are relevant to the individual. By examining needs information across users, the Shopping Aid will be able to suggest additional needs that are common among people like the user, and to make recommendations for upgrading choices when the probably benefit exceeds the individual's cost of change.

Keywords: GPII, Supported Decision Making, Federated Database, Shopping Aid.

1 Introduction to the Problem

The conventional computer interface is designed by and for young, healthy adults, with normal movement, senses, and cognitive skills. While this group includes a majority of the workforce, and especially the computer and software development workforce, it does not include many of the people who require computer access in the modern world. Computer use is becoming virtually ubiquitous in modern society. In 1999, virtually all businesses in the state of Kentucky used computers in some way [1]. By 2011, 75.6 percent of American households included a computer, and 71.7 percent had in-home internet access [2]. However, people with disabilities and the aging have significantly lower access to computers and the Internet than do their younger, healthier associates. In Australia, in 2011, 96% of 18-24 year olds reported computer and internet access, compared with less than half of those 65 years or older. Just over half of adults with disabilities reported having access to computers [3]. As computers become a mainstream means of access to education, commerce, government services, and medicine, access to computers becomes increasingly essential to participation in society.

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Almost from the introduction of the personal computer, it was applied to the needs of individuals with disabilities [4, 5]. However, many of the early computer applications were special, adapted programs for people with disabilities[6, 7], which did not provide access to the same programs and services enjoyed and used by able-bodied computer users. Not until the advent of the Adaptive Firmware Card for the Apple II [8, 9] could a person with a disability have access to the same programs as his/her non-disabled peers. Since then, some hundreds to thousands of methods of providing access to information technologies have been developed and marketed.

Given the wide range of available accommodations, why are elderly and/or disabled people only half as likely to be using computers as their able-bodied peers? While the cost of accommodation may be a factor, very functional examples of on-screen keyboards, magnifiers, and screen-readers, among other accommodations, are available at no cost. A more common contributing cause is the lack of appropriate information about available accommodations for those who need them most. Many providers of assistive technology services work in the school or medical systems. However, many of those who would benefit from access accommodations are not enrolled in schools, or do not have access to advanced medical systems. While it is possible to obtain information through skilled Internet searches, the people who need computer accommodations don't have advanced computer skills!

1.1 Distributed Information about Accommodations

A person who needs accommodation to successfully use information technologies has two fundamental problems to address before a solution can be found. First, the individual must determine what sort of accommodation might be required. This requires an explanation of the difficulty experienced in using an information appliance. In many cases, the individual has neither the insight to characterize his/her experience nor the vocabulary to explain it to an AT specialist. Since the individual does not know what the "normal" experience might be, s/he cannot easily describe how his/her experience is not normal. Lacking training in human performance, s/he may not be able to accurately describe the experience. Most non-professionals, in discussing visual deficits, for example, may describe problems as having "double-vision" or "out of focus" (needing glasses), but has no way to describe visual field cuts, reduced sensitivity of the retina (it's dark!), or astigmatism. Second, because most AT listings are based on the function of the device, the individual must have some idea that it is possible to address this problem, and what the solution might be in order to begin the search.

The next problem involves finding a potential solution to the problem being experienced. Information about computer access technologies is currently available from a wide range of sources in varying degrees of detail. The European Assistive Technology Information Network (EASTIN) maintains an online database of assistive technologies (http://www.eastin.eu/en-GB/searches/products/index) organized broadly on ISO codes. AbleData (http://www.abledata.com), funded by the U.S. Department of Education through the National Institute on Disability and Rehabilitation Research, also provides a broad ranging database of almost 40,000 products, organized by life

skill. In both cases, the information about a specific product is very limited, and does not readily support decision-making. More focused assistive technology databases such as The Toolbox (http://www.agrability.org/toolbox/), a database of farm related technologies, or the product databases maintained by Microsoft or the American Foundation for the Blind are much narrower in focus, but may provide more information about the included assistive technologies. None of the available databases provides sufficient information to support product selection about a wide range of products.

2 Federating Data Sources

Federation is a process, often political, of bringing independent entities together into a common group, while continuing to allow independent operation. The Global Public Inclusive Infrastructure (GPII) Unified Listing is a federated database combining information from a wide range of sources into a single shared database. The information sharing of the Unified Listing is bidirectional. While the Unified Listing replicates content from contributing sources, it also allows those sources to replicate Unified Listing records that are relevant to the audience of those sources. The database of the American Foundation of the Blind, for example, may replicate records in the Unified Listing that have been contributed by other organizations who are concerned with providing access to blind consumers, but would not be interested in adaptations contributed by Microsoft related to on-screen keyboards from Windows 8.

2.1 Challenges of AT Federation

There are two primary difficulties in combining information from diverse sources about assistive technology. Different groups or manufacturers may use different terms to mean the same thing, and in other places, use the same word to mean different things.

As an example of how different terms are used for the same thing, consider the rate at which speech synthesizers produce speech. Speech synthesis is used for Augmentative and Alternative Communication devices, where the requirement is to be understood by naïve listeners, and in screen readers, where the requirement is to provide blind users familiar with the voice with reading speeds that are commensurate with those of sighted colleagues. An objective measure of speech rate would be the number of words spoken from a standard source in one minute. Without a standard source, however, words spoken per minute can be variable. Unfortunately, manufacturers may use neither the same terms, nor the same scales. JAWS for Windows, for example, includes an adjustment for “Rate,” which slides from 40 to 150. The normal speech rate seems to be around 70 on this scale, while 150 appears to be many hundreds of words per minute. ZoomText 8.1 also has a Rate: adjustment, which ranges from 50 to 250, and appears to be approximately words per minute spoken. OS X, on the other hand, has an adjustment for “Speaking Rate” which scales, like Windows,

from “Slow” to “Fast,” with “Normal” at midscale. It is unclear whether these scales are linear, logarithmic, or merely scalar.

An example of the same word being used to mean different things is provided by the example of “word prediction.” Early assistive technology attempted to “guess” the word that the user was typing based on the first few letters that had been typed. This feature was termed either “word completion” or “word prediction,” with the latter term being used most often. As the technology advanced, it became possible to guess not only the word being typed, but the word or words most likely to follow. With this expansion of capability, some AT professionals began referring to predicting the current word as “word completion,” reserving the term “word prediction” for the ability to predict the most likely word following the current word. However, “word prediction” continues to be used for both processes by manufacturers and practitioners in the field.

The issue of different (unique) terms being used for the same feature can be resolved by developing an assistive technology thesaurus. This will involved developing a canonical listing of terms to describe features of assistive technology and user interface adjustments, then matching variants to those canonical terms. The issue of the same term being used for different features will require developing standard “operational definitions” of each of the features and settings for assistive technology that can be used to match individual product functions.

We have to determine how best to handle data conflicts between different sources. Some of these data conflicts will arise from errors made during data entry. If the same device resides in three or more databases, it may be possible to rectify much of the data by “majority rules,” since it is unlikely that the same typographical error will occur in more than one database. In cases where errors cannot be easily resolved, it will be necessary to flag the record for review. Another type of data conflict may arise from different applications of a product. Many of the needs of a person with low-vision are similar to those of a person with learning disabilities when consuming text content. Some products may be used in both populations, but be described differently, based on the orientation of the individual describing the product. The easiest way to control for this type of data conflict would be for the GPII Unified Listing database to focus on objective measurements, and not attempt to include measures of suitability for any type of disability. This would conflict with the needs of the Shopping Aid (described below), suggesting that another solution must be found, possibly requiring flagging conflicts for resolution by human staff.

3 Decision Support – The GPII Shopping Aid

The Unified Listing will attempt to contain information about all assistive technology products and all device settings that affect the usability of information and communication technologies, and usability adjustments of consumer electronic devices. This will make the information necessary to make a decision about product selection available to the user of the Unified Listing. Unfortunately, it will also make a vast amount

of unnecessary information available. The result of this wealth of information could be severe information overload.

The concept of information overload has been recognized since the 1960s, though it has been suggested much earlier [10-15]. The problem is that, when presented with a choice between a small set of options, individuals may be able to make a meaningful choices. When presented with many options, the ability to make choices is limited. The individual cannot process all of the available choices, so becomes unable to select any of the offerings. In order to make meaningful choices between options, most people do not require more information; they require more focused, relevant information, and less information about inappropriate topics. The challenge is to differentiate relevant from inappropriate information for each individual.

The GPII Shopping Aid, an on-line decision assistance tool, attempts to limit overload by pre-filtering information based on what the individual has communicated, so that the choices are both fewer and more relevant to the individual user.

There are three routes of access to the GPII Shopping Aid Decision tool. First, the individual may use the Discovery Aid, an access evaluation tool that can be used either independently or with the assistance of an assistive technology professional to identify access needs. The Discovery Aid will identify components of the technology interface that present barriers, but will not attempt to find solutions. On completion of the Discovery Aid, the needs profile will be transmitted securely to the Shopping Aid. Alternatively, for those individuals who are able to work with an AT professional, the clinician can select the desired AT functions after evaluation to produce a functional profile of the individual. Finally, the sophisticated user may directly describe functional needs to the system.

In each case, the Shopping Aid will draw from the Unified Listing those products that address the identified needs of the user. These can be sorted by the number of needs addressed, or by the match to user preferred (not necessary) features.

3.1 The Language of Assistive Technology Intervention

One of the challenges in assistive technology provision is that different groups think about intervention in different ways. Three key groups to be addressed by the GPII Shopping Aid are device/system manufacturers, AT specialists and clinicians (who may not be AT specialists), and end-users of assistive technology. Each of these groups thinks about assistive technology in different ways.

Device manufacturers may, in product development, think about the functional needs of their products, but this quickly is translated into product feature descriptions. For example, the introduction of ZoomText 10[1] describes that product as having five new features, including "Background Reader, ZoomText Recorder, ZommText Camera, Enhanced WebFinder, and Read from pointer." A competing product, MAGic[2]

[1] AI Squared, 130 Taconic Business Park Road, Manchester Center, Vermont 05255, Phone +1 (802) 362-3612.

[2] Freedom Scientific, 11800 31st Court North St. Petersburg, FL 33716-1805, Phone: 1-877-775-9474 (within US).

describes its features as including "change how colors appear on your screen, apply tinting, make your screen display in monochrome, and invert the brightness and color of the display." As products develop, much of the development occurs by the addition of new features, so that more mature products have a large and diverse features set.

Assistive Technology providers and clinicians who may provide assistive technology on occasion do not select products based on the feature set of any product, but on the functional needs of a specific client. After evaluating a client, the AT practitioner may determine that this person would benefit from a word prediction program that provides in-line prediction, and which presents the words in alphabetical order. While a product that includes word prediction as one of many features may be among the products considered, the complexity of controlling a wide range of features may make it less desirable to the AT user than more focused, but easier to configure, products. For AT providers, the inclusion of a wide range of features does not necessarily increase the desirability of a product. The practitioner considers primarily the feature or features that match the needs of a specific individual.

End users, in the majority of cases, have little experience in the range of variation that is available in user interfaces, either natively or through add-on assistive technology. The primary awareness of the end user is that certain tasks on certain devices are difficult or impossible. The thinking of the typical end-user is needs or difficulty based: I need to perform this task and can't, or this operation is difficult for me. Most consumers of assistive technology will not be able to describe why a task is difficult, only that it is.

While it may be reasonable to expect AT practitioners to learn how assistive technology features work, and the language that is used to describe them, the same is not true of the clinician who only recommends assistive technology sporadically, and even less so for individuals who need assistive technology for their own use. Some means of addressing the needs of different audiences must be found.

3.2 The Janus Interface

Janus, the Roman god of transitions, is depicted as having two faces, so that he looks to the future and the past at the same time. The GPII Shopping Aid will have multiple faces, looking toward specific user groups.

For technology developers and manufacturers, the Aid will allow navigation by features. A manufacturer might search, for example, for all assistive technologies that offer in-line word prediction. Another might seek products that read text from the screen, and that highlight each word as it is spoken. This search would allow a developer to direct limited resources into the likely most-profitable features, or to determine if a "new" feature had already been developed by someone else.

For assistive technology providers, the GPII Shopping aid will have a function oriented interface. Using this interface, the AT provider will be able to provide a set of desired functional abilities, and receive a listing of product that provide one or more of the functions needed. When the provider selects a product from the list, competing products that provide the same functionality are subtracted from the list,

allowing the user to easily select the set of products (one or more) that provide the functional capabilities require by the client.

For the end user, a very different interface is required. Here, the GPII Shopping Aid allows the individual to indicate the tasks that are difficult, or features that are desired. In this interface, the user will be able to describe features that are required, and those that are desired. For example, a user might indicate that words on the computer screen are too small to read, and it would be helpful if they were a different color. Using this information, the GPII Shopping Aid can provide a list of products with the required features, ordered by the number of desired features that are included.

In keeping with the requirement to avoid cognitive overload, each interface will allow the user to select a broad category of requirements, and drill down to specific features. In this way, no user will be confronted with the hundreds of potential accommodations. Each user will see the few accommodations that are relevant to a specific search.

Additional interfaces may be developed to meet the unique needs of different user groups. For example, library staff members are often asked to assist patrons in setting up computers within a library. These staff may or may not have functional limitations themselves, but are unlikely to have the level of understanding of disability and assistive technology of a clinician who even rarely provides AT services. For such users, an interface with different types of requirements, using a different vocabulary may need to be developed. However, once the basic mechanisms of the Janus Interface are realized, adding additional interfaces will be easier.

3.3 Auto-suggest Features

Historically, recommendations of assistive technologies have been based on at most the experience of a single AT provider. There has been no way to combine the experience of practitioners around the world, or to compare potential solutions for the individual. The unique structure of GPII allows a level of understanding of individual human-computer interaction and interface accommodation that has not previously been possible. This understanding arises spontaneously from the portability features of GPII.

Each user of GPII has a personal preference file that is stored in the cloud, and delivered to the device being used on demand. This file includes the needs profile of the user as well as the specific licenses owned by the user, and the devices and settings that are preferred. This information allows GPII to configure each system the individual uses to match the specific needs of that person. The stored needs profile also allows the individual to return to the Shopping Aid to find new solutions if a selected product proves unsatisfactory over time. The combined information of many GPII preference files makes unique information available.

Assistive Technology Syndromes and "People Like You". In medicine, collections of signs and symptoms that tend to occur together are identified as syndromes. If a person shows a number of the indicators of a syndrome, this can predict the

occurrence of other symptoms of the syndrome that may be covert. For example, the flattened face, upward slant of the eyes, and low muscle tone of a newborn are indicators that the child may have Down syndrome, and may also indicate the presence of cardiac abnormalities that frequently accompany that condition.

It is probable that there are analogous patterns of assistive technology need. For example, a person who lives with Type II diabetes may have visual changes that require the use of enlarged print, or in extreme cases, a screen reader. Such a person may also require keyboard accommodations because of reduced sensation and mobility in the hands. The visual changes of normal aging (presbyopia) are often accompanied by changes in hearing (presbycusis) as well. Beyond these trivial associations it is likely that there are more complex interactions of needed accommodation.

The GPII preference files offer the opportunity to identify patterns of needs that occur among users of assistive technology. If such patterns can be identified, we will be able to match the individual needs identified by GPII users to the identified patterns of common needs. When an individual uses the Shopping Aid to select assistive technologies, they may have identified a portion of a common pattern, but failed to consider a developing issue, or one which they had not identified as outside the norm. In these cases, the Shopping Aid may ask, "Many people like you also indicate that they also have difficulty with [additional need]. Would you be interested in looking a products that make that task easier?" If the user does not have the identified additional need, they can ignore or dismiss the suggestion. But if they do, they may find use of information and communication devices much easier.

Goodness of Fit and Improved Solutions. In many cases, the assistive technology solutions selected by an individual with functional limitations provide necessary access, but not equivalent access. In some cases, assistive technology does not currently exist to meet the specific needs of the individual. In other cases, there may be compatibility issues between "best case" solutions. In these, and other cases, it will be possible to create a "goodness-of-fit" metric to describe the extent to which an individual's current assistive technology solutions meet the identified needs of that individual's personal preference profile.

Over time, new assistive technology products are introduced, or existing products are updated to provide additional functionality. Matching the new capabilities of assistive technology over time will allow prediction of improvements in this goodness-of-fit that are available, and to suggest to the user that they may wish to look at new or updated versions of their assistive technology solutions.

Few things in ecommerce are more annoying that the constant barrage of emails generated by on-line vendors. After purchasing a product, a customer receives a stream of emails saying, "We saw that you were looking at this product. You might be interested in these…" These email contain a variety of products, often including the item just purchased or other products with exactly the same functionality. Often the recommendations are for incompatible models of the device purchased. The purchaser of a Nikon lens might receive suggestions for Canon lenses of similar focal length. From a vendor viewpoint, only a very small "hit rate" makes these emails cost

effective, since the cost of generate a custom email is very low. But for the customer, they can be very distracting and counter-productive.

To avoid this constant annoyance, we plan to develop a companion to the goodness-of-fit metric, which we are calling "Changeability." Some individuals, commonly known as "early adopters," enjoy trying new approaches to tasks, and are happy to be notified of new things to try. For others, the energy expended in integrating an assistive technology into their activities is substantial, and they are loath to change. In still other cases, a person may be very busy with their daily tasks, and simply not have the time to invest in learning a new accommodation, even if, over the long term, it produces savings in time that exceed the investment.

We propose to develop a "Changeability" metric for users of GPII. This metric will indicate the willingness to try new approaches given an expected return. This may be a multidimensional metric, or as simple as a slider ranging from "You're bothering me" to "Why didn't I know about this sooner!" Ultimately, the Changeability metric will translate into a threshold change in goodness-of-fit. When new versions or new products would allow a configuration of assistive technologies to exceed that of an individual's current selections, they will be notified that better solutions now exist, and they may wish to consider them.

To minimize the risk of hounding GPII users excessively, we can monitor response to these suggestions. If an individual ignores two or more alerting messages, it is likely that the current setting for Changeability is too high, and it can be incrementally decreased. If the individual repeatedly responds to alerting messages with visits to the Shopping Aid, even if they do not change their technology, this can be taken as an indication that they are not satisfied with their current solutions, and are willing to change. Additionally, if the individual clicks a "Why didn't I know about this?" button, that can be an indication of willingness to try new things. In either case, the Changeability setting might be incrementally increased. Over time, the frequency and probable impact of messages will adapt to the level that is desired by each individual user.

4 Conclusions

Currently, an individual seeking access solutions faces daunting challenges. Manufacturers describe their products through their features. Different manufacturers may use different words for the same feature, or the same word to describe different features. Assistive technology practitioners and clinicians must translate the manufacturing terminology into functions that match the needs of their clients. End users may not have access to assistive technology professionals (indeed, may not even know that such exist), may not be able to effectively describe their experience, and lack the vocabulary to make effective selections from the available products.

The Global Public Inclusive Infrastructure (GPII) is a world-changing approach to providing accommodations for individuals who have difficulty using the standard interface of information or communication technologies. With GPII, the individual can determine the type of interface that works for them in one location, and those

same accommodations can follow them wherever they go. For this to work, the individual needs an effective way to tell the system what assistive technologies they prefer to use, and how those technologies should be configured.

Together, the Unified Listing and the GPII Shopping Aid provide an entry point to use of the GPII. The Unified Listing, a federated database of accommodations for information and communication devices, provides an encyclopedic view of available accommodations. Combining the information that is currently available in both broad and specialized databases of AT solutions into a single source allows the GPII to meet the needs of virtually any individual for whom a solution currently exists. The GPII Shopping Aid filters this knowledge to provide the information that is relevant to the individual, and at each step, to hide the information (cognitive noise) that is not relevant to the individual's needs.

As the number of users of GPII increases, the accumulated information will allow development of two enhanced features. First, we will be able to generate information about "people like you," allowing recommendations for needs that the user did not mention, either because they were not aware of the need, or aware that solutions were possible. Second, through a "goodness-of-fit" metric and "personal changeability" measure, we will be able to recommend possible improvements in the assistive technology solutions of a user only when the potential benefit is large enough to be worth the effort for that individual.

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