Winds of Change
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intro

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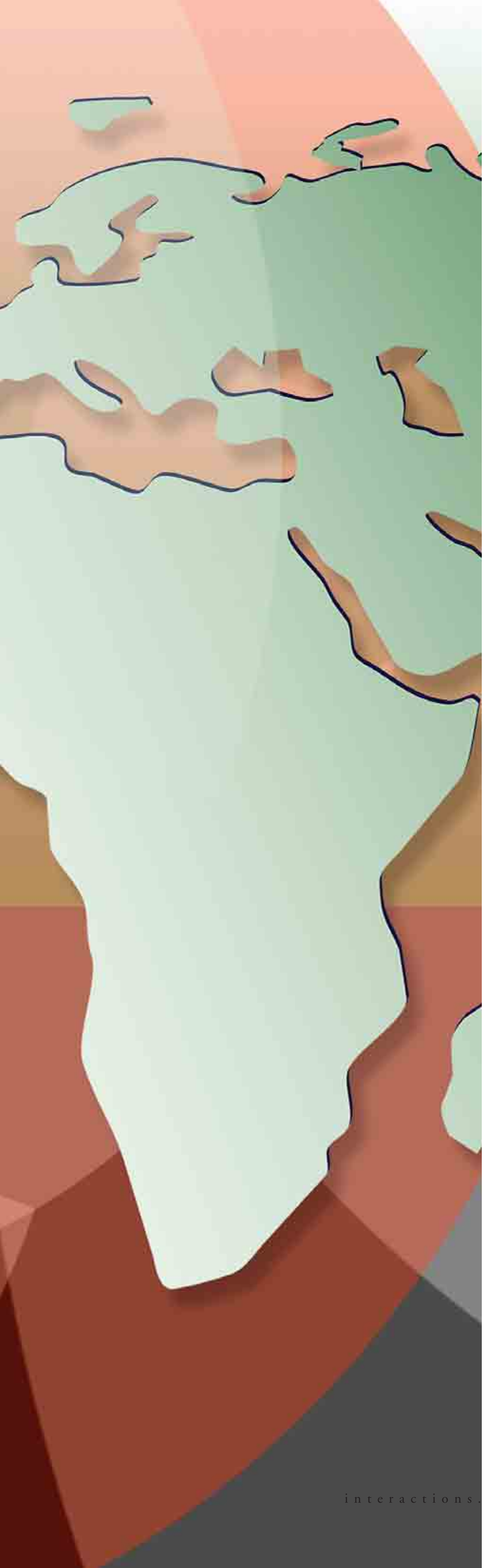

Indra's Net: HCI in the Developing World

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Introduction

There is a legend that once, long ago, a net was thrown over all the peoples of the world. This net had bells sewn on at every junction, so that the movement of any person in any place would set the bells jingling, reminding all people of their connection to each other. In the Indian version of this legend, this is Indra's Net—and instead of bells, it is jewels which are sewn into the net. When the net is moved, each jewel glimmers, reflecting the beauty of all. How fitting that, today, the net—this time the Internet—should now span the globe, reminding us of our interconnectedness with the world!

But for many in the so-called "developing world," the Internet remains a distant or even unknown thing. Indeed, the technology and infrastructure that underlies much of the success of the "developed world" is all but nonexistent in many

places. For instance, in Africa, where the gulf is probably the widest today, estimates for access to computers range from 1 in 130 [8] to as few as three per 1000 in sub-Saharan Africa [1]. Many of these computers are used by multiple people, but even so, optimistic estimates suggest that only 1 in 160 use the Internet [1]. Globally, Internet use is still "disproportionately white, educated and affluent" [1]. The gap in access to information and communication technologies (ICTs) between the developed and the so-called developing world is huge. Even within developing countries, the gap between the most affluent and educated (who can be as technologically "enfranchised" as the inhabitants of California or Germany) and the poor is enormous. And, despite efforts to address it, the disparity in Internet usage is increasing over time. Even though all countries, even the poorest, are increasing their use of ICTs, the world's richest countries, the so-called "information-haves," are increasing their use at much faster rates. At the same time, people in information-rich countries can afford to upgrade, expand, and develop additional skills with new technologies, further exacerbating the disparity. As a result, "the rich get richer and the poor get poorer" as the digital divide grows [2, 4].

So what does this have to do with us, as Human-Computer Interaction (HCI) professionals? Of course the digital divide is not simply a problem of human-computer interaction. It reflects profound inequalities in the distribution of wealth, educational opportunity, and technology infrastructure. However, initiatives to address the digital divide will have to also address those issues that are central concerns of HCI: How to improve the fit between technology, specific human needs, and human contexts; how to design technology to facilitate human interaction with it; and how best to manage the process of technology introduction.

Despite the small numbers of HCI people in the developing world, they are generating a large number of innovative ideas and important projects. As believers in and practitioners of user-centered design (UCD), they are acting as agents of change—empowering users in traditionally under-served or even unserved populations, finding ways to leverage this empowerment to expand the opportunities available to those whose voices are rarely heard, and having an impact on the future directions, not only of technology, but of their nations.

This special issue of *interactions* is devoted to sharing a small sample of the important HCI work happening in the developing world. The idea for this issue grew out of the Development Consortium for South Africa which took place at CHI 2002 in Minneapolis, chaired by Jacques Hugo and Theo Bothma. For this issue, however, we have expanded the focus to include colleagues from India, Brazil, and China. As we learned about these and other projects, we found a wonderful richness and diversity of experience.

The Complex Technology Landscape

While the digital divide is one important concern, it is not the only reason to be interested in and supportive of HCI work in the developing world. HCI in the developing world is not merely about dealing with technological deprivation. For example, in the global economy, technologies originating in the developed countries are expanding into the developing world and need to be adapted to a wider range of users and situations than ever before. Exports from the developed world may not fit so well into the culture of other countries. They may need tailoring of functionality, content, visual design, and/or overall interaction design to work in their users' contexts. We (Dray and Siegel) saw a fairly simple example of this when working with a client who produced a complex and sensitive system that integrated information processing with electro-mechanical peripheral devices. The engineers who produced this device were accustomed to working in a dust-free, climate-controlled environment, and envisioned their system being used in corporate or industrial settings, not too different from what they were familiar with. They discovered from international user studies that some of their customers were using their devices in tents in hot, dusty, desert environments, far from sources of replacement parts and repair technicians. It is questionable whether the HCI community based in the developed world can ever obtain the necessary knowledge of local users around the world. We need HCI partners in the developing world to help us understand their special circumstances and their users.

The need for technology to work internationally is not limited to products exported from the developed world. Despite the persistent digital divide, the evolution and proliferation of ICTs is in fact increasingly knitting together people from diverse backgrounds and contexts. As Derrick Cogburn discusses in his article in this issue, the people doing geographically distributed work in the global economy are linked by information systems, which must work for users from different backgrounds, cultures, and contexts. These systems must also take into account the needs created by the new social dynamics of distributed work.

Another technology trend, which Derrick refers to, is the growing international trade in services, including information services. Specifically, services and information systems which will be utilized by users in the developed world are being

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designed and built in the developing world. This creates a number of challenges for the design and development process, challenges that HCI is particularly attuned to. For example, Pradeep Henry's article discusses the challenges of providing design input into software development projects being carried out in India for offshore customers. He also describes the approaches that he and his team at Cognizant have adopted to deal with such challenges, such as geographical dispersal of the team and geographical separation from users.

The dominant technology platforms, or the mix of platforms in use in different countries, or among different socio-economic groups within countries differ from what people in the developed world may assume. For example, many factors in some countries promote the adoption of less expensive ICTs, such as cell phones. In fact, in many or most "developing" countries, cell phone penetration far exceeds computer penetration. Therefore, HCI professionals may focus on different types of interface design and become specialists in the UCD challenges associated with these technologies, such as the very small displays on cell phones. Key advances in these domains may be very likely to emerge from the developing world. In this issue, Gary Marsden describes interesting work that his group at the University of Cape Town has done in this area, responding to the importance of cell phone technology in the South African context.

In most **"developing"** countries, **cell phone** penetration far exceeds **computer** penetration.

HCI in Technology Initiatives for Indigenous Development

There are a large number of fascinating projects related to development of ICTs for indigenous use in developing countries, some of which we have learned about through our work on this issue. There is a wide range of efforts under way to develop useful systems on a variety of platforms, such as kiosks, cell phones, PDAs and other handheld devices, as well as desktop computers. Interface paradigms that people in the developed world may take for granted may not be appropriate or workable for these projects. The result is a great deal of HCI creativity. The HISAAB project in India is developing computer systems to support village collectives engaged in microfinance initiatives. It is a joint project of Media Lab Asia (MIT) and the India-based HCI professionals from Human Factors International. (Thanks to Apala Chavran for bringing this to our attention.) You can read about this project and their user-centered design activities at the two HISAAB Web sites listed in the References [5, 6]. For several years, Hewlett-Packard has supported what they call world e-inclusion projects aimed at using appropriate information technologies to foster economic development [7]. For example, one of these, the Digital Garage, is a project in São Paulo, Brazil which teaches underprivileged youth how to use a wide range of computer equipment. In this environment, they learn from a team of technical experts who help them develop their own creative projects in a safe environment. Another, the Dikhatole Digital Village, will provide access and training in use of the Internet to residents of a township east of Johannesburg, South Africa [7,10].

These projects are often motivated partly or largely by the noble desire to use technology to advance social and economic development. The fact that they are aimed at groups that are so obviously disenfranchised technologically can put HCI on center stage in these efforts. When designing a system for a user group that has no computer experience and who may be marginally literate, it is hard to overlook the need for user-centered design (as is all too often the case when designers let themselves off the hook for bad design by relying on their users' presumed familiarity with similar systems). However, development projects motivated by "higher goals" such as general economic development, run the risks of all top-down design efforts, namely, that the goals of the sponsoring authority are often not the same as the more concrete and immediate goals of the end users. It is understandable that governments and agencies would see technological development as an essential step in national development and as an inherent good, but we all know situations where "throwing technology at a problem" simply resulted in un-used systems, because the systems did not meet real users' immediate needs or did not fit the usage context. HCI has a crucial role to play in bridging the meta-goals of national development and the needs of actual users. Clarisse de Sousa, Raquel O. Prates, and Simone Barbosa tell the story of how and why they had to introduce UCD approaches into a project that was a response to a national mandate.

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The Challenge of Limited HCI Resources

Many of us in HCI struggle with getting the ear of "the powers that be" in order to get into development processes at the right time to make a contribution to system design and development. In many cases, we must educate developers, managers, or funding bodies, to make the case that a focus on the user is critical-and to illustrate how we can do this in time- and cost-effective ways to improve design. Most of us feel that there are not enough HCI people and not sufficient resources to have the full impact that we know we could and should have.

The challenge of resources takes on new meaning in the developing world. The demographics of the

HCI communities in "developing" countries differ in interesting ways from those in developed countries, and from each other. In countries where HCI is primarily an academic endeavor, such as South Africa, there are persistent questions about "What happens to our graduates? What can they do when there are no HCI jobs in industry?" It also may lead to somewhat more applied research being conducted in academic settings, as these researchers seek to balance their theoretical interests with the pressing "real world" needs of their countries. In other countries where there is not a strong academic HCI community, such as India, a very different set of questions arises including "Where can we get (more) training in HCI? Who can do the basic research needed to advance HCI in our context? How will we recruit and train additional HCI professionals? How can we get universities interested in this interdisciplinary area to build competence and excellence in HCI?"

The issue of "critical mass" is an important one, since the HCI communities in the developing world are very small and may be isolated geographically from each other. HCI is an interdisciplinary profession and when there's a very small community, it can be hard to have enough people from all the different disciplines in HCI, such as psychology or anthropology, to create a truly interdisciplinary perspective. To date, most HCI people in the "developing" world are computer scientists and most HCI programs are in computer science departments, so the methodologies of social sciences (e.g., statistics and statistical reasoning, experimental design, ethnography, etc.) are not as well known. This is an area where more open dialogue across boundaries—both geographic and philosophical—is important to support HCI community growth and development. The range of technology and interface issues that the HCI community addresses is huge, with tremendous cross-fertilization. This cross-fertilization can be more difficult to achieve in a small, geographically isolated professional community, as well.

HCI communities in the developing world are very small and may be **isolated geographically** from each other.

These issues are addressed in the separate articles by Pradeep Henry and Jian Wang. Pradeep also discusses the efforts of the HCI group at Cognizant to maximize their impact with limited resources.

Diversity of Language and Mental Models

Although there are certainly similarities in the challenges we face, there are also many very significant and interesting differences which show up when you compare the research focuses between HCI in the developed and developing worlds, as well as how HCI in the developing world responds to the issues closest to home. Some examples of these have to do with research on language and mental models of non-western users. For many populations in these countries, many of the interface paradigms considered "standard" in the developed world simply are not applicable. Therefore, HCI professionals must adopt new and innovative approaches which are tailored to the resources and culture in which they work. By doing so, they may expand the envelope for everyone, including people in technology-rich locations.

Literacy and broader linguistics issues are examples of a research domain which is a "specialty" of developing countries. "Computer literacy" is not even the first challenge—the basic skill of reading is. Most user interfaces today require at least a basic grasp of written language. While this is a "given" in many "developed" countries, this cannot be assumed in most "developing" parts of the world. As recently as 2000, UNESCO estimated that more than half of young and adult populations in many developing countries are illiterate, with two-thirds of these being girls and women. Although this number has been declining in some regions, estimates are that almost 25 percent of the world's population is still illiterate [9]. When we expand the concept of literacy to include computer literacy, the figures will be even less favorable. Obviously, interface designs that are based on assumptions about shared knowledge of standard interface paradigms are likely to fail, or reach only very limited audiences.

An example of innovative work on development of interfaces for non-literate users is provided by Edwin Blake and his group of the University of Cape Town [3], and also presented at the Development Consortium at CHI 2002. They worked closely with expert South African San (Bushman) trackers, developing a palm-based system for tracking animals, utilizing the trackers' incredibly rich knowledge of animals and animal behavior. This device, called the CyberTracker, was developed in a user-centered, iterative design process, and was used experimentally in several South African wildlife conservation parks. Its design makes limited use of words, heavy use of images, and organizes information in a non-hierarchical manner. The CyberTracker has allowed the wildlife management and conservation community access to the skills and knowledge of these trackers, despite their functional illiteracy. This project has led not only to increased recognition for these trackers' skills, but also to a more systematic and valuable utilization of these skills by the conservation managers of the national parks.

If we are to bring the largest number of groups into the technology revolution, we must recognize that there are profound differences among the world's languages, at the level of how the structure of the language codes information. The languages of the developed world do not provide a universal model. The field of natural language interfaces can only benefit from broadening the spectrum of languages we pay attention to. The article in this issue by Laurette Pretorius and Sonja Bosch gives an idea of the magnitude of basic linguistic research needed to develop language parsers for neglected languages, such as the Bantu languages. There are also profound differences among writing systems in different countries, which introduce challenges for text entry, and call for more specialized interface issues such as handwriting recognition. In his article, Jian Wang describes some of the work that has been done in China to develop methods for text input adapted to the Chinese idiographic writing system, in addition to giving an overview of the current state of development of HCI in China.

Differences in how languages structure information relate to differences in how people organize information mentally. This provides a natural bridge into the cross-cultural study of mental models. Obviously, differences in how people mentally organize their world are difficult to assess, and likely to be related to complex differences in culture, experience, education, environment, and common concerns. Identifying the user interface (UI) design implications of such differences may not only help in developing usable technology for more diverse groups, but may also ultimately help spur UI innovations. It stands to reason that research into this challenging area is likely to be the most productive when we can learn about people from the most diverse backgrounds possible. Obviously, the developing world provides a fertile field for such work. The article by Marion Walton and Vera Vukovic in this issue comes out of this focus in HCI.

Final Words

There are many lessons to be learned here—for all of us in HCI, regardless of whether we live in Minneapolis, Munich, Montevideo, Mumbai, Melbourne, Mafikeng, or Mombassa. As editors, we have learned a lot from these authors, and we hope you share our excitement as you read of their insights and solutions to incredibly complex problems in HCI, and take away lessons for your own work, just as we did.

Technology can knit the world together or it can create a schism. HCI has a key role in bringing people together, no matter where they live. Since HCI professionals all over the world find themselves facing some of the same challenges, we can and must support and learn from each other, sharing the things which work for each of us, and suggesting alternatives that others may not have yet tried. The promise of HCI as a global endeavor is one reason that HCI in the developing world matters. But another is that HCI practitioners everywhere stand to learn from the efforts of their developing world colleagues as they respond to their particular challenges.

ABOUT THE AUTHORS

Susan Dray is President and David Siegel is Vice President of Dray & Associates, Inc., a user-centered design consulting firm. Their firm has worked in 17 countries, which has contributed to their international perspective on HCI. Susan was a keynote speaker at CHI-SA in 2001, and at the South African Institute of Computer Scientists and Information Technologists (SAICSIT) Conference in 2002. They have recently contributed a chapter on doing international usability research to a forthcoming volume tentatively entitled Cross-cultural User Interface Design, *edited by Nuray Aykin, and scheduled for publication by Lawrence Erlbaum Associates in Summer, 2003. They are also co-editors of interactions' Business Column. David and Susan both have Ph.D.'s in Psychology from UCLA. Susan is a Board-certified Human Factors Professional.*

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A NOTE ABOUT TERMS:

We have used the terms "so-called developing/developed world" and "developing" world in this article interchangeably. We are aware that many in this part of the world find the term "developing" to be somewhat negative or pejorative, in part because it is sometimes used with value judgments of lesser worth by those in the so-called "developed" world. We are using the terms simply as descriptors, with no value judgment implied.

Advancing UCD While Facing Challenges Working from Offshore

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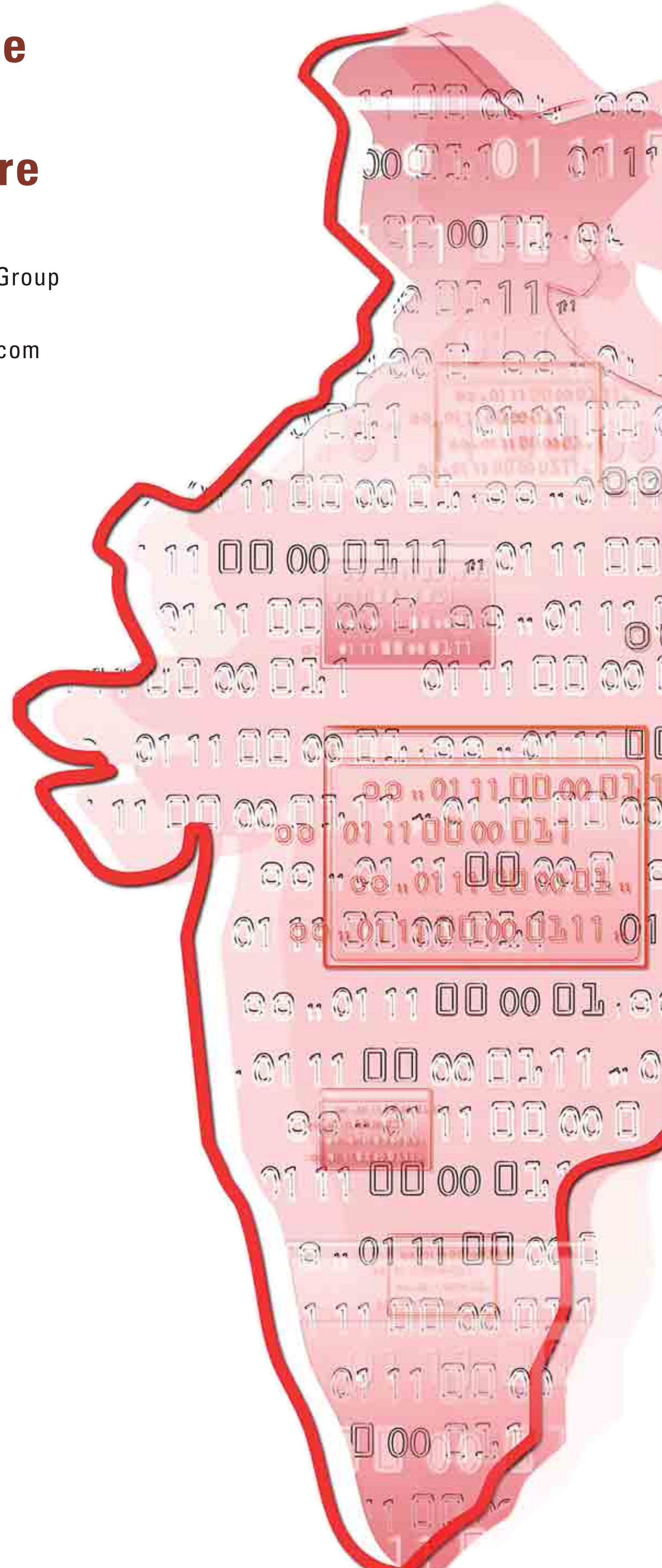
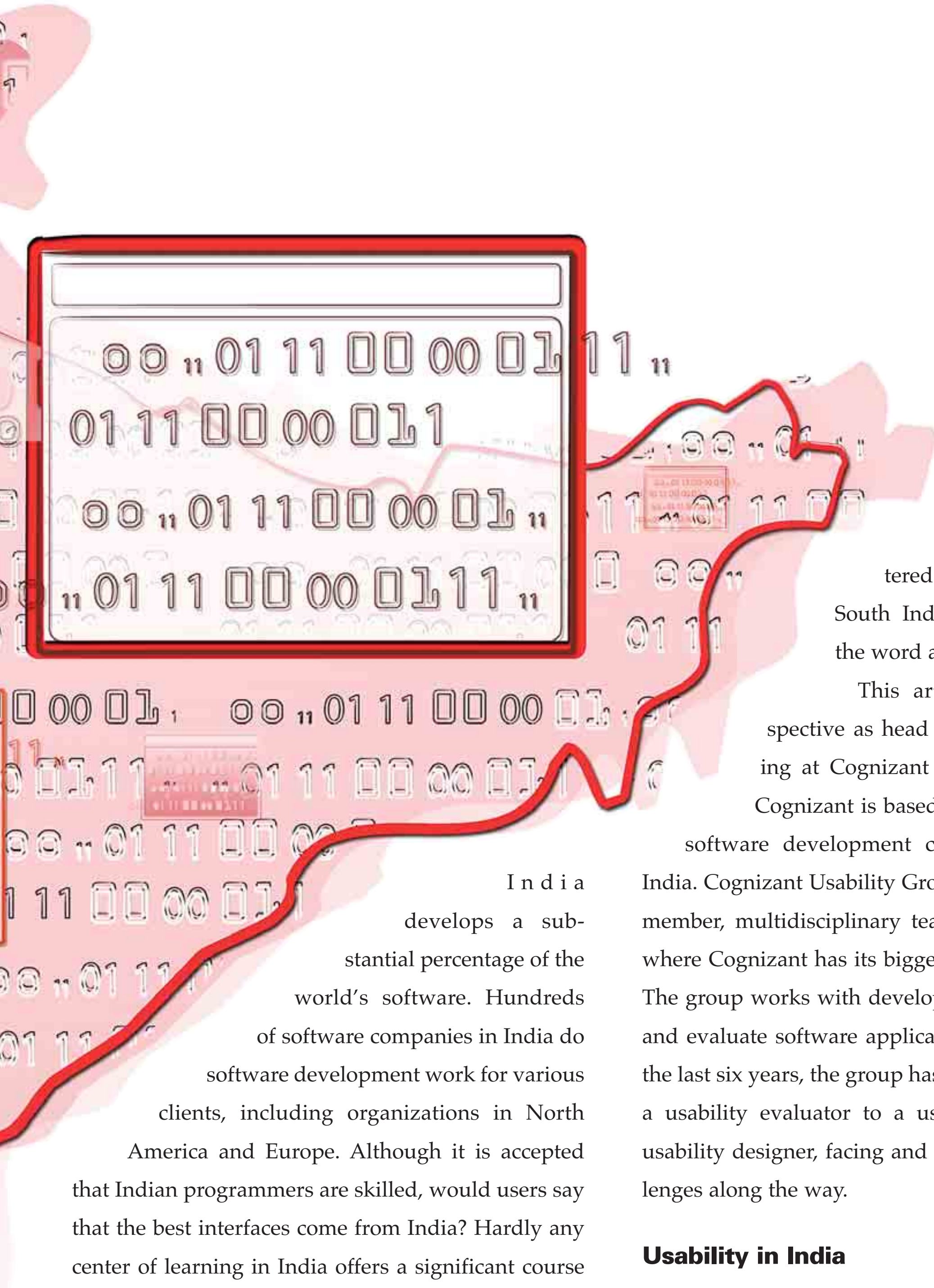




India develops a substantial percentage of the world's software. Hundreds of software companies in India do software development work for various clients, including organizations in North America and Europe. Although it is accepted that Indian programmers are skilled, would users say that the best interfaces come from India? Hardly any center of learning in India offers a significant course in human-computer interaction (HCI) or usability. Most of the technically savvy programmers are unaware of principles and techniques of good design. Further, myths that impede good design are rampant.

In spite of all these negative factors, one or two companies are doing good usability work, adapting offshore usability models and actually advancing the usability discipline by doing some pioneering work. This good news is sure to be extended to include many more companies as ACM-chartered organizations like CHI South India continue to spread the word across the country.

This article reflects my perspective as head of usability engineering at Cognizant Technology Solutions. Cognizant is based in New Jersey, but its software development centers are located in India. Cognizant Usability Group is a centralized, 10-member, multidisciplinary team located in Madras, where Cognizant has its biggest development center. The group works with development teams to design and evaluate software application user interfaces. In the last six years, the group has moved up from being a usability evaluator to a usability improver to a usability designer, facing and addressing many challenges along the way.

Usability in India

India faces the challenge of misconceptions about interface design that are common among developers. These include myths about usability, and a mistaken model of interface design that leads to a system-oriented rather than a user-oriented approach.

Myriad Myths

In India, HCI may be confronting many or all of the same usability misconceptions that exist in other countries. In my experience, the following three myths, however, stand out as causing the most damage.

1. "Pretty screens are all you need." Since the DotCom boom days, many companies in India, as in the West, have tended to think that designing a good user interface means designing pretty-looking screens. Unfortunately, some of their clients too have demanded pretty looks above all else. Companies that advertise for "usability specialists" end up hiring graphic designers, who are typically the only ones that respond to the ads. Sadly, many of these people are not even likely to be formally trained as professional graphic designers. They are instead experts in operating a graphic tool such as Adobe Photoshop, having recently "graduated" from one of the Web design courses that have sprung up all over India. At best, these people deliver attractive screens, as "make it attractive" is often their only single objective.

HCI people in India need to continue spreading the word that there is no substitute for the contribution of trained usability engineers.

2. "I can design on my own; just give me some guidelines." Often, software development teams simply ask for guidelines so they can design interfaces themselves. Other times they ask for checklists and templates or perhaps a two-day training course. These requests reveal a belief that achieving usability is a matter of learning and applying a few simple rules. Such rules may be enough to help them achieve relatively smaller things like correct placement of buttons. But software development teams need to ask themselves if they can really achieve a well-structured menu by using a checklist or ensure easy navigation merely by following some guidelines. HCI people in India need to continue spreading the word that there is no substitute for the contribution of trained usability engineers.

3. "Usability is about testing:" When I first set up the usability lab at Cognizant in India, I made an all-too-common mistake. I called my team Usability Lab. The problem is that when people see the testing facility and the equipment, they start equating usability with testing. Adding to that, they read and believe what many popular usability experts talk so much about—testing. As we know, it is often more efficient to invest in good design practices than in testing alone. Unfortunately, equating usability with testing leads people to believe that programmers or graphic designers should continue to design the user interface and that usability specialists should be consulted only later for testing.

The Cognizant development organization in India is increasingly under pressure from clients to deliver usable interfaces but need more education about what this requires. First, we frequently conduct road shows in Cognizant divisions all over India, primarily aimed at software project managers. Here, we not only share before-and-after examples that demonstrate the value of usability engineering, we also explain the projected return on investment for Cognizant's clients. People slowly learn, for example, the relative higher importance of quick navigation versus, say, the "prettiness" of screens—when the artifact in question is a software application for serious business use. Second, Cognizant usability engineers discourage requests for things like guidelines and checklists by explaining through examples why they may not help substantially improve design. Finally, the idea that usability is synonymous with testing is fading. Of course, the first thing I did toward debunking this myth was to change the group name from Usability Lab to Cognizant Usability Group!

> **A system-oriented approach deprives users of the many potential benefits that can otherwise result from a user-centered approach.**

Mistaken Model

At most Indian software companies, programmers design the user interfaces. Indian programmers are sound technically and enjoy doing technical work such as database design. Their top priority is to get their programs to work correctly. When they are required to design the user interface, however, they naturally find it hard to switch from system-thinking to thinking from the user's viewpoint. Moreover, they are unlikely to know user-centered design techniques, because hardly any institution in India currently teaches HCI design as part of computer science programs.

When such professionals design the user interface, their inspiration is often the system's internal design. For example, the user interface might get structured the way the database is structured. Programmers typically prefer this approach because they do not need to invent a design from scratch—and they can implement the design easily. As we know, such a system-oriented approach deprives users and buyer organizations of the many potential benefits that can otherwise result from a user-centered approach.

At Cognizant, to replace the system-oriented, user-*interface* design practice with a user-*centered* design approach, we did two things:

1. Integrated the process. Working with Cognizant's Process and Quality Management group, we integrated a user-centered design process with the company's SEI CMM Level 5 software engineering process.

2. Hired and trained usability engineers. Replacing a system viewpoint with a user viewpoint not only requires a process, but, more important, the right people to apply that process. As I stated earlier, the challenge I faced in hiring is that India has few people educated in HCI or usability. Therefore, I hired a few who were educated in the United States. The rest of the team consists of people from different related disciplines whom I have personally trained.

Offshore Usability Engineering

Offshore usability engineering, by definition, is about applying usability methods at a location where actual or representative users are not available. The idea of offshore usability engineering certainly sounds like a paradox, and the approach faces obvious challenges. But given the realities of offshore software development, Indian-based HCI still has an important positive contribution to make for buyer organizations.

In Jakob Nielsen's September 16, 2002, *Alertbox* column (www.useit.com/alertbox/), he says that offshore usability work in a country like India can present potential difficulties such as:

- Lack of usability professionals
- Local users are not representative
- Separation of usability professionals from users

The rest of this article analyzes these three challenges and discusses some of the strategies we have been using to address them and to contribute HCI expertise to offshore development projects.

To put it briefly, we have worked to solve the first problem by hiring academically qualified usability engineers, such as people trained at an American university. We address the second problem by either conducting tests in the "home" country or using recruitment methods that ensure that you have closely matching local users for your tests. Finally, we approach the third problem by having an appropriate onsite-offshore model. The problem is that solving all three of these together is quite hard and takes time. Let's examine each challenge more closely.

Challenge 1: Lack of Usability Professionals

Hiring HCI people for offshore projects is important for the same reason that hiring them is important for projects done entirely at home. For offshore projects, a lack of academically trained usability professionals in India is the fundamental problem. One obvious reason for this is the lack of formal HCI training in India. Therefore, creating a usability group requires pulling together a group with diverse skills and helping them both to focus those skills on HCI and to acquire new knowledge in HCI.

At Cognizant we addressed this challenge by assembling a group of people with university education in industrial design, architecture, psychology, technical communication, graphic design, and computer science. People in the group who have HCI and related education acquired from American universities work to pass that knowledge on. Three of the 10 team members have worked in the United States and therefore also have some understanding of cultural differences.

Challenge 2: Local Users Are Not Representative

Clients and prospects from the West who have visited Cognizant's usability lab in Madras have said, "It's great to know you do usability testing here, but how do you handle the cultural differences?" More specifically, they were asking if it makes sense to use Indians as representative users when the typical actual user is a white male between 25 and 30. Here's how we addressed this issue.

1. Before we start any test, we put a great deal of effort into understanding the users and how they perform their business tasks. We try to take this information into account when analyzing our test results.

2. We use a recruiting procedure to ensure that people we bring in as test users closely match real users in the "home" country. For this we use a form that captures user profiles and another form that prospective users fill out. We compare these two and select only people whose profiles closely match those of real users. For example, if the software application being tested is used by undergraduate clerks in a bank in the United States, we hire undergraduate clerks from banks in India. We know that it makes better sense to have the actual users "test" the product. Because of who Cognizant's clients are, this means conducting the test in North America or Europe. We use this method when the client agrees to fund the expense of India-based usability engineers traveling to the "home" country to conduct tests there.

3. If we test in India, some culture-specific design issues may still remain unmet. From experience, we've seen that those unmet issues are often related to colors and similar visual design issues. Such issues may not significantly affect user performance, and they can be relatively easy to correct based on feedback from actual users. We get such feedback by making the application available to the real users. This approach does not always produce the ideal result. Often, it is the head of a user group or a client representative who finds time to provide the feedback. Also, these are typically reviews, rather than formal usability tests, although client-managed tests do happen in a few projects.

Creating a **usability group** requires pulling together a group with **diverse skills** and helping them to **focus** on HCI and to acquire **new knowledge** in HCI.

Challenge 3: Separation of
Usability Professionals from Users

Offshore software development, in spite of its cost and other advantages, has one obvious downside—that is, the geographical separation of the development team from the client and user organizations. For offshore HCI work, this could mean poor understanding of users or inability to conduct reviews and tests with real users. Therefore, the resulting user interfaces may not necessarily be tailored to the target users.

As we have learned more about how to deal with this issue of geographical separation, the role of our usability team in development projects has evolved. At Cognizant we first started by conducting usability inspections offshore and delivering reports that listed design problems. Although the development team was able to implement the few easily actionable points in our report, they tended to ignore the points that required extensive thought and redesign. As a result of this experience, in the first few projects, we started delivering redesign solutions too, based on our inspection findings. The development teams were startled to see the difference we made in the designs, and they appreciated our work but did not find the time and people to implement total redesigns that we recommended. Instead, they made the easier-to-implement changes, which were often just minor improvements. Thankfully, we are now in our third generation. In our current approach, we have assumed actual lead responsibility for design of the user interface for the development team. Now our role is more clearly defined and our efforts are estimated and billed to clients.

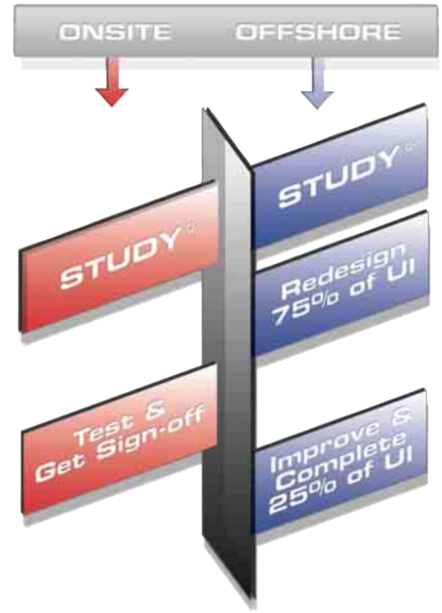
India is 10 to 12 time zones away from the United States! Can modern-day tools such as phone and e-mail help? They do, and we use them a lot, but they are not enough. In the first several projects, we had trouble getting information about what kind of people we were designing or redesigning for. What doesn't work effectively is depending on the offshore development team for knowledge about users or use scenarios. Development teams have many things to worry about, and knowing users well might not be at the top of their list. In such cases, the India-based HCI team should try to have users fill out detailed user profile questionnaires and conduct telephone interviews.

Gradually during the past four years we have also evolved a more systematic division of labor that we call the "onsite-offshore model." This means that activities that need close interaction with client and users are done at the client or user site, and other activities are performed "offshore" in India.

The following list is an onsite-offshore model that is a modified version of the one shown in Figure 1. We used this version in our most recent project for a U.S. client:

1. Study (onsite and offshore): At project kickoff, our India-based usability engineer traveled to the United States and used such HCI methods as user profiling and task analysis to understand not only users, but also the workflow and tasks, users' goals for performing those tasks, and use scenarios. He created a task description document and got client sign-off on personas and scenarios, all of which will be used as inputs for design work that will largely happen in India. In parallel, one offshore usability engineer tried to

Figure 1. An onsite-offshore model for redesigning user interfaces, assuming that the offshore usability team has high quality design skills and good exposure to the culture of target users.



understand the application by participating in development team meetings and reading available product documents.

2. Prototype design (onsite; about 30 percent of the design effort): Frequently consulting with the offshore multidisciplinary team, the onsite Cognizant usability engineer created a prototype user interface.

3. Prototype evaluation (onsite). The onsite usability engineer administered usability tests of the prototype with our client's customers (that is, actual users) in two U.S. cities. Only audio recording was done in these tests conducted at the user site. The usability engineer improved the user interface based on test results and got client sign-off on the design.

4. Complete design (offshore; about 70 percent of the design effort): Currently the rest of the user interface is being designed by the lead usability engineer, who has returned to India after spending two months in the United States. Completing this process in India allows us to put more usability resources to work (including the person who conducted the offshore study) to quickly complete the HCI design project. During this part of the process, we will also obtain user interface evaluations through client reviews and through peer reviews by the multidisciplinary offshore (that is, India-based) usability team.

One interesting thing that happened in this phase was the administration of a remote usability test! The client wanted further evaluation of the prototype and so administered a couple of more tests. Downloading special software that the client had subscribed to, the Cognizant usability engineer "participated" in these tests remotely.

Turning the Challenges into Clients' Advantage

Offshore usability that involves significant efforts in a country where labor costs are lower brings cost savings to buyer organizations. However, offshore usability itself is not automatically advantageous when the quality of the user interface is a major concern for the client. In fact, we've seen that it can pose some big challenges. For offshore usability to work, the offshore vendor, at a minimum, needs to have a trained usability team and must work with an effective onsite-offshore model. Thankfully, if these requirements are met, clients do get a much more meaningful interface than they would otherwise. And in a rare scenario where the offshore team has world-class usability engineering skills and applies a tightly coupled onsite-offshore model, the client can get the double advantages of a user-centered interface and financial benefits.

Project Example

Cognizant Usability Group believes that the user interface architecture—often comprising menu struc-

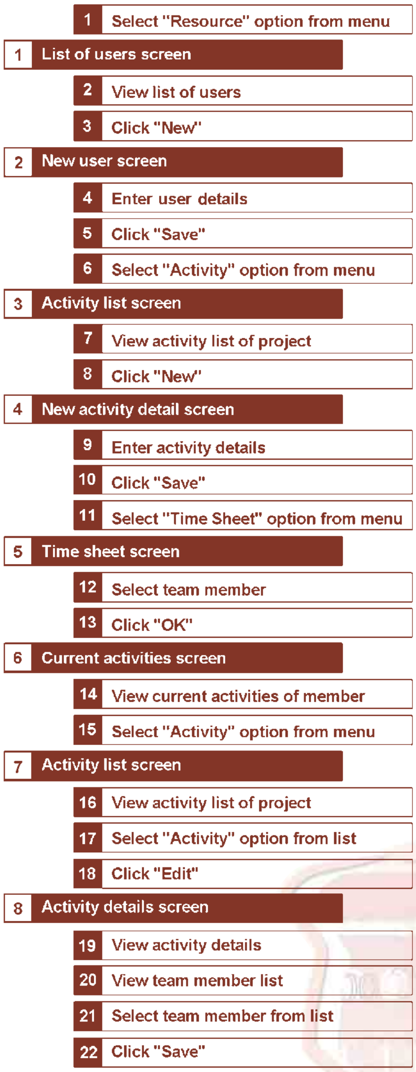


Figure 2. An example dialog from the original user interface.

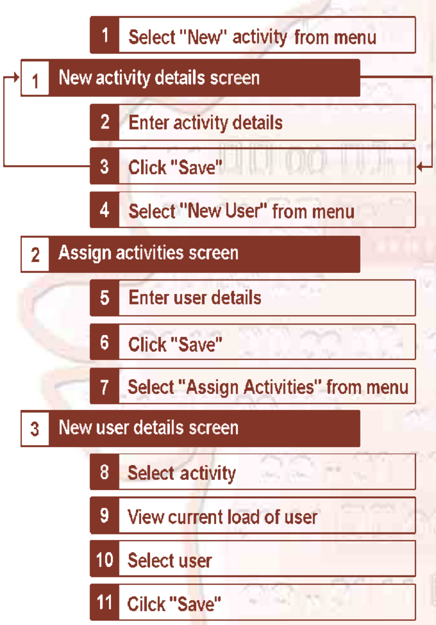


Figure 3. Dialog outline as redesigned.

tures and dialog structures—is most important and fundamental and must be designed first. Only after the user interface architecture is decided do we start working on other aspects of design.

This approach has helped Cognizant develop high-performance interfaces for its North American and European clients. In redesign projects, the productivity improvement has been as high as the 50 to 200 percent range, and even up to 500 percent and higher for individual tasks. We followed this approach in testing and redesigning the user interface for a project management Application Service Provider (ASP) Web site. Consider a scenario in which a project manager needs to create 10 activities and assign those activities to 10 team members weekly for 24 weeks (the duration of the project).

Original User Interface: In the foregoing project, the original design required 22 steps and eight screens for a project manager to create and allocate activities. This task must be repeated for each activity. Figure 2 shows the sequence of steps and screens required with the original design.

Redesigned User Interface The steps and screens required with Cognizant Usability Group's redesign are illustrated in Figure 3.

In this figure only Steps 2 and 3 and Screen 1 must be repeated for each activity to be created. All users can be created in the same screen (Screen 2), and all assignments can be completed in another single screen (Screen 3).

Resulting Business Value

The number of steps required to complete the preceding task was reduced from 220 to 29, and the number of screens that the user needed to navigate through was reduced from 80 to 12. Suppose it takes a conservative two seconds for each step and two seconds for each screen download, in both designs. For a project duration of 24 calendar weeks, we estimated that a project manager would spend four hours with the original design, whereas the same user would spend only 0.5 hour with the Cognizant redesigned user interface, all other things being equal. This means that the user organization would potentially gain an eightfold increase in productivity for that task over an interface developed without HCI input.

Such dramatic potential productivity improvements were also estimated to come from the many other tasks and scenarios we addressed in this application's interface design. Besides, we expect many other benefits to be realized, such as a sharp decrease in (1) the number of user errors; (2) the learning curve, thereby eliminating or reducing hassles and expenses related to user training; and (3) the size of help and manuals.

Conclusion

At this time, most software companies in India are a long way from user-centered design. When these companies begin focusing on users, software that comes from India will not only be technically strong and bug-free but usable as well. In this way, HCI promises to make a great contribution to India's growing technology industry.

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Pradeep set up India's first usability lab in January 1999 at Cognizant Technology Solutions' Madras development center. He currently leads the organization's usability team. Pradeep has worked mostly on projects for companies in North America and Europe, contributing to the design or redesign of user interfaces for business applications in vertical markets such as insurance, banking, healthcare, transportation, and retail. Pradeep is founder and chairman of CHI South India, the ACM-chartered chapter that is focused in India's equivalent of Silicon Valley: Bangalore, Madras, and Hyderabad.

Using HCI to Leverage Communication Technology

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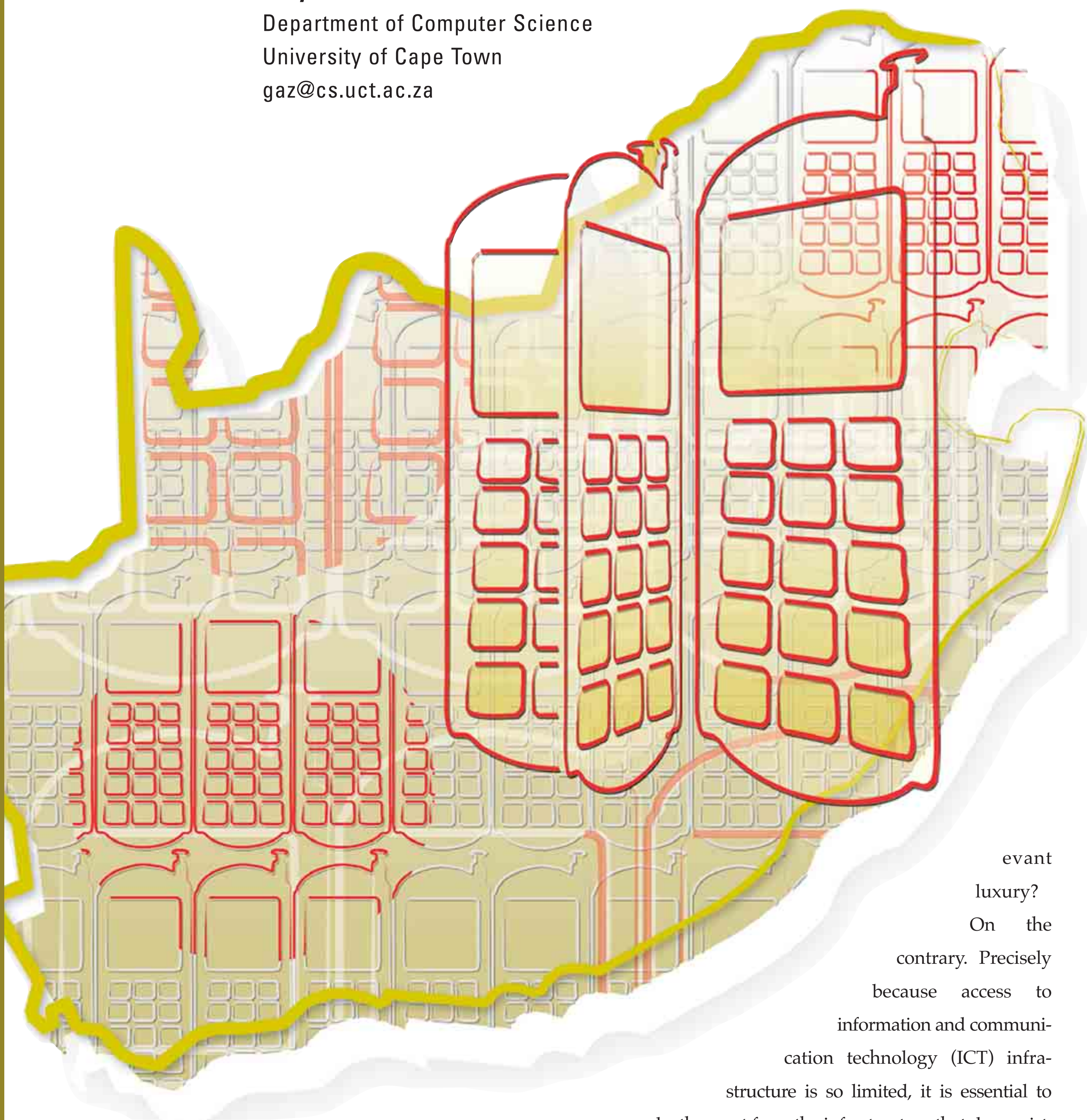

What is the benefit of human-computer interaction (HCI) to a developing country? On a continent where an estimated one in 130 people has access to a personal computer (PC) [3], surely interface design is an irrelevant luxury? On the contrary. Precisely because access to information and communication technology (ICT) infrastructure is so limited, it is essential to make the most from the infrastructure that does exist. Human-computer interaction (HCI) has a large role to play in empowering users and adapting technology to local needs. Among South Africans such empowerment is seen as key to our country's future. The following is taken from an address given by the South African president, Mr. Thabo Mbeki, to the G7 summit in 1995 [6]:

"...it is clear that bringing the developing world on to the information superhighway constitutes a colossal challenge. We have to address the challenge nevertheless, if we are to promote economic growth and development worldwide, consolidate democracy and human rights, increase the capacity of ordinary people to participate in governance, encourage restitution of conflicts by negotiation rather than war and do what has to be done to enable all to gain access to the best in human civilization, within the common neighborhood in which we all live."

So how does one tackle such a challenge?

If we are going to make useful information available to a wide group of people, two key issues need to be addressed:

- **Content:** Although it contains a lot of useful information, the Web is currently clogged with irrelevant and unhelpful information. If the Web is to become a useful tool, then some way needs to be found to filter out material that is not useful and better catalog the material that could be useful.
- **Access:** Typically, a personal computer is required to access the Internet. Expensive, bulky, fragile, and requiring large amounts of power, the personal computer does not seem like an ideal candidate for providing universal access.

Tackling the problem of access first, after television and radio, the one piece of communication technology that most South Africans have access to is the cellular telephone network. In a country where only 11 percent of the population is sufficiently wealthy to pay income tax [10], some 27 percent of the population owns a cellular handset [9]. This is a rare example of the much heralded technology-leapfrogging by developing countries, where the new cellular technology has made the older, cable-based telephone network obsolete (only 11.4 percent of South Africans have access to a fixed-line handset [2]—a pattern repeated in many other developing countries). Furthermore, South Africa is experiencing urbanization, so a large percentage of the population has no fixed abode from which to access land-based telecommunications.

As multimedia messaging services (MMS) and connected digital assistants (like the XDA) currently drive the cellular market in European countries, we in the developing world are somewhat lower on the technology feeding chain and are still purchasing wireless application protocol (WAP) handsets. Although WAP may not be the ideal way to connect to the Internet [8], we believe it is better than no connection at all.

Providing Content

To be an effective tool, not just an entertainment medium, information on the Web needs to be edited, categorized, and stored in a concise and easily searchable way. Although this may seem like a pipe dream, it describes exactly the goal of digital libraries. We have been working with the New Zealand Digital Library Group [7], which has, in turn, been working with the

United Nations and the United Nations Education, Scientific, and Cultural Organization (UNESCO) to develop digital library collections for the developing world. To date they have developed collections such as the Human Development Library, Food and Nutrition Library, and the Medical and Health Library, which are published using Greenstone Digital Library software. These libraries, and many others, contain information that is highly valuable to any developing country. Witten *et al*. [13] list all the collections available on Greenstone for developing countries (some 3,590 in total). The article also points out the costs and benefits to developing countries of delivering information in this way—for example, the Human Development Library alone contains some 1,230 publications, and in print would weigh 340 kg (almost 750 lb.) and cost $20,000 USD!

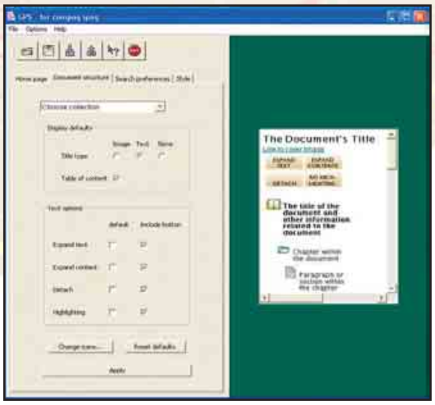

Figure 1. Customization tool for digital libraries.

Distribution

All interaction with Greenstone is currently conducted via hypertext transfer protocol (HTTP) and hypertext markup language (HTML). To bridge the gap with WAP and wireless markup language (WML), we installed a proxy server, details of which can be found in Marsden *et al.* [5]. We were able to generate sensible WML because the Greenstone content is well defined and regular in structure. Having built the server, we had to tackle a variety of usability issues that are not easily solvable. Each issue was tackled using heuristic evaluation with a selection of Web literate users (who were not familiar with digital libraries per se).

Document Structure

Digital library documents tend to be arranged in a hierarchy: collection, document, chapter, section, and so forth. There is a convention of indention to display this information. However, indention on a WAP device is not easily achieved because several of the browsers we worked with ignore white space. After trying a variety of solutions we discovered that the minus sign (-) forced indention without cluttering the display.

Also, when a user browses Greenstone, only the section headings of a document are retrieved. On our system, we used a plus sign (+) to denote an open branch and a minus sign (-) to denote a closed branch. This caused problems in the usability tests because users familiar with Windows Explorer associated a plus with expanding a branch and a minus with collapsing a branch. Once we altered the design to conform to Windows, users no longer stumbled on expanding and collapsing branches.

Browser

We used several browsers in our evaluation and discovered that each had a different interpretation of the

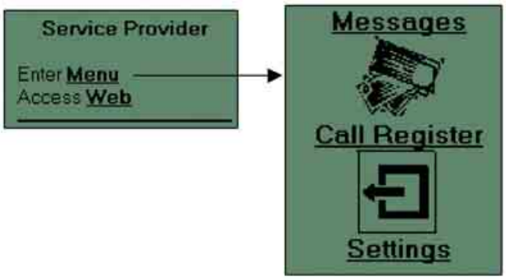

Figure 2. The handset home page (left) allows local and menu access. Selecting the Menu option will present the user with a screen (right) that allows the user access to the normal menu system.

WML standard. We found browsers for which the Back button did not work; browsers that placed buttons in arbitrary screen positions, and browsers that did not display hyperlinks longer than the screen width. Although these are implementation issues, one usability issue common to most browsers was the indication of scrolling. When a page exceeded more than one screen, our users would often not scroll down. When asked about this, most responded they had no idea that there was more information (unless there was an incomplete sentence or other accidental cue). The reason users did not scroll was related to the small size of the scroll bar on most WAP browsers. Designed to take up as little screen area as possible, these widgets are barely noticeable, providing no feedback to the user on the length of the page. If usability of WAP is to improve, then scroll bars need to remind users that more information may be hidden beyond the bottom of the screen.

More fundamental **research** is needed on how information can be **structured** and **presented** to those not familiar with **document conventions**.

Digital Libraries

After watching our subjects struggle to retrieve information with our system, we conducted some usability tests with the full, HTML version of Greenstone. Our results showed that some usability issues lay with Greenstone, rather than being artifacts of our system. As our target users have had little experience with libraries, let alone digital ones, we discovered that the basic metaphor of information structure (for example, chapter, section, subsection) proved problematic.

If digital libraries are to make an impact beyond English-speaking, computer-literate users, then several interesting questions need to be answered. It is clear that a simple translation (into a local language) of the interface will not be enough; more fundamental research is needed on how information can be structured and presented to those not familiar with document conventions. Our preliminary work, reported elsewhere in this issue [12], has shown that many cultures struggle with the concept of hierarchies (subjects were unable to draw a simple family tree).

As it stands, our system follows the conventions of the Web and Web searching. This has greatly improved system usability, to the extent that Web-literate users can perform meaningful queries and retrieve useful

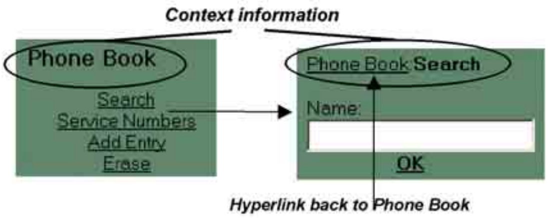

Figure 3. The menu allows several options to be viewed simultaneously. Also, context information can be used for navigation as in an HTML-based Web site.

results. The issues of WAP browser and digital library design still remain. We are confident that as mobile Internet access becomes more common, the usability of mobile browser software will improve. The work of altering digital libraries for use in developing countries, however, has no direct commercial benefit and is only likely to happen, therefore, as an academically motivated project. Currently we are focusing our efforts on building a high-level customization tool that lets novice users create and customize their own collection. In Figure 1 the output is being formatted for a personal digital assistant (PDA) screen.

Cellular Handsets

Besides the usability issues directly related to WAP, we observed that users struggled when switching between WAP and the menu structure of the handset. If handsets do have a browser installed, it would seem sensible to eliminate the menu structure and replace it with a series of WML decks. By doing this, we free the user from having to learn two types of interface; the navigation techniques they learn for the browser can be transferred to navigating the functionality of the handset. To investigate the possibility of providing a WAP interface, we have built a number of prototype systems.

WML Prototypes

The simplest way to replace menu systems is to create WML pages corresponding directly to existing structures. We have already built such a system based on the Nokia 5110, as shown in Figure 2. This prototype presents the user with a home page providing access to handset information or a remote site. If the user selects **Enter Menu**, he or she is presented with the WML pages replacing the menu system. In this way, the menu becomes just another site accessible through the browser. The only interactional benefit of this prototype, however, is that the navigation keys and paradigm for the menu system are identical to those required for a WML browser.

To improve interaction further, we modified the WML to present as many options as possible on the screen at any one time. We then used indention to provide the user with context information about their choices (see Figure 3). In this way, we have created a system that exploits best practice in displaying hierarchical menus and keeps the navigational benefits of the previous prototype.

Both of the prototypes described earlier are based on the structure of current menuing systems. Re-using the structure in this way allows current handset users to transfer their knowledge to the browser-based system. However, as the options are presented as WML pages, it would be straightforward for handset manufacturers to provide users with a WML editor to restructure the menu system any way they choose. This would allow users to exploit the benefits of a graph-based structure and overcome problems of hierarchical classification.

Research [11] was carried out to consider the impact of reducing the size of the display to a menu system. The smaller the display, the fewer options were presented; users had to scroll the list to see any options not shown initially. Although the time it took users to select an option increased as the display size decreased, the

Figure 4. Display from Ericsson R320 showing menu title and three options.

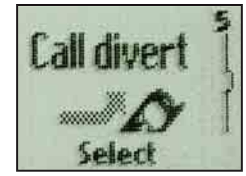

Figure 5. Nokia root-level icon.

impact was not dramatic. Real problems occurred, however, when the display was so small that only one option could be displayed at a time—error rates increased dramatically, and the time taken to access functions was significantly reduced. Therefore, handsets that display more than one option at a time (ideally three or more) have performance characteristics similar to those of desktop systems. A device that displays only one option at a time will be disproportionately more difficult to use.

It appears that cellular handset designers are unaware of this research, because they persist in producing handsets that display only one option at a time. Although some handsets are so small that they support only a single-line screen (for instance, Ericsson T28), others have a large screen capable of displaying multiple options but choose not to do so (any current Nokia or Motorola). To improve interaction, Ericsson adopted a menu system that displays three options simultaneously on the screen (see Figure 4).

Visualization

The benefits of visualization of state in interfaces are well understood. Therefore, one way to improve usage of menus is to give the user visual feedback about where in the menu structure she is. This orientation may be attempted in several ways.

Icons

In the devices examined as part of this work, icons were found to exist in two formats: isolated and context.

Isolated icons are those used to augment understanding of a particular menu items. For instance, Nokia menu systems since the 5110 have displayed an icon beside each of the root-level menu options (see Figure 5). It is not at all obvious what purpose these icons serve, because they are not used in any other context and cannot be manipulated in the same way as icons in a Windows, Icon, Menu, and Pointer (WIMP) environment. More recent releases of Nokia handsets include animated versions of these icons. Research conducted on animated icons for desktop systems suggests that they are most useful to explain some action or verb [1]. However, of the root-level options that have animated icons, only one option is a verb—Call Divert. Even with this option, the animation adds little to understand-

In South Africa, **improving** the user's **experience** only requires the **reworking** of current **solutions**.

ing the role of the menu, because it shows an arrow ricocheting off a small picture of the handset. From our analysis, we can conclude only that isolated icons serve as a marketing feature and add little to the usability of the handset.

Context icons are used to highlight a particular choice from a set of alternatives. Rather than showing a single menu option per screen, context icons can be used to display the full set of alternative choices on a single line; the compact icons can be fitted on the screen where the larger text representations cannot. This type of icon has been used in a curious way in the current range of Ericsson handsets. Rather than exploit these icons to reduce the amount of screen real estate required, the icons are used in conjunction with the text description of each menu option. Although redundant information is helpful to users, the screen space could, perhaps, have been used in more helpful ways: an extra menu option or a scrolling help line, for example. When a suboption is selected, the icon disappears, meaning that the longer text name is used at the top of the screen to describe the submenu. Retaining the icon would be particularly useful for providing context in sub-submenus.

Context Information

For novices using a menu, it is essential that they be provided with some form of feedback about where they are within the structure in order to navigate successfully. The limited screen resources of the cellular handset make this a much more difficult task than with desktop—based menu systems. Given that some of the handsets we examined nested menus up to four levels deep, the problem of navigation becomes all the more complicated.

In the handsets we examined, Nokia provided the most information about location in a menu structure—not only depth choices, but also feedback on the current level. The least information was provided by the Ericsson handsets, which showed only the most recent category choice. This is curious because Ericsson goes to extra lengths to provide smooth scrolling when changing menu levels to provide users with as much contextual and spatial information as possible.

One vital piece of information missing from these visualizations is feedback about which options in the menus are branch nodes (the selection of which will display another menu) or leaf nodes (the selection of which will access a function). From desktop menus we already have an ellipsis (or triangle) convention to denote the difference; leaf nodes have no ellipses beside the name. This type of information is important to novice users exploring a menu structure. They will be more likely to explore the structure if they know their exploration will not affect the handset.

Manuals

Manuals for cellular handsets have limited usefulness; the manual is usually larger than the device itself. Because the point of cellular communication is mobility, it is unlikely that users will carry the manual with the device. Furthermore, research by Youngs [14] shows us that younger users (under 35) are *less* likely to complete a task if they use the manual.

Online manuals, however, can be much more successful. Here, if a user scrolls to a menu option and does not select it, a scrolling description or a piece of stretch text for that option appears on the screen. For example, Lee *et al.* [4] found that adding extra information to menu options could reduce errors by up to 82 percent. Online help was applied seemingly randomly for the handsets we examined; help was provided according to the model and was not consistent for a particular manufacturer.

Conclusion

This article detailed the importance of cellular technology in South Africa and how that technology can be adapted to better improve the user's experience and, it is hoped, extend the functionality of the device into new domains. These adaptations require no new technology, merely the reworking of current solutions.

The work presented in this article is symptomatic of the type of HCI research flourishing at the University of Cape Town and other South African institutions. What may be considered a limitation in developing countries—a lack of computing equipment and Internet access—has been found by us to be a boon. Through necessity we have been forced to focus on the human side of the HCI equation, and that focus has helped reveal shortcomings in technology (such as cellular handsets) that would otherwise have gone unnoticed.

ABOUT THE AUTHOR

Gary Marsden has a Ph.D. in HCI from the University of Stirling in Scotland. He was part of the Interaction Design Centre at Middlesex University in London for three years before moving to the University of Cape Town in 1999 where he is now an Associate Professor. He currently works on a variety of interaction design problems in South Africa ranging from mobile computing to virtual reality systems.

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Enabling Computer Interaction in the Indigenous Languages of South Africa: The Central Role of Computational Morphology

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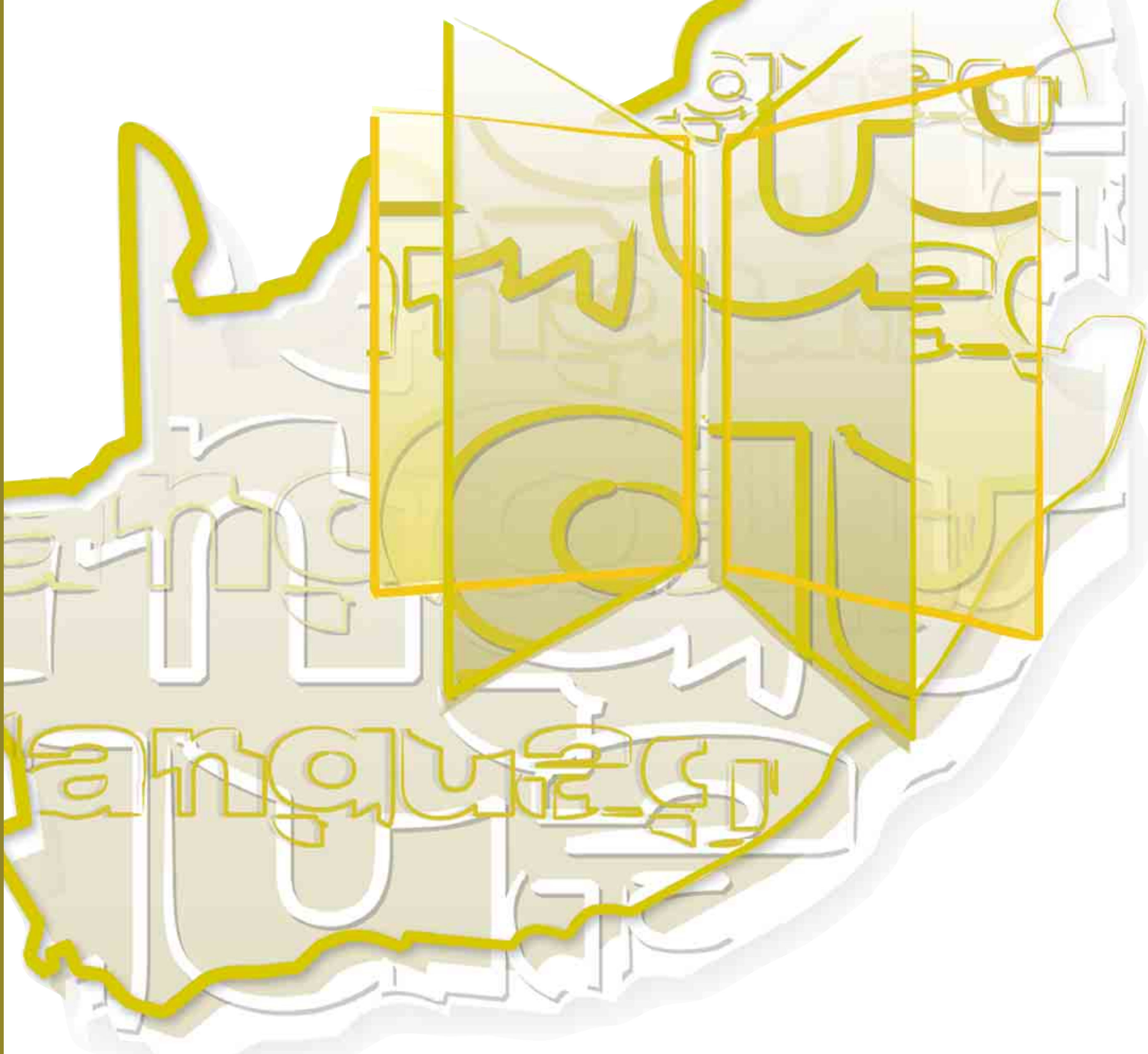

Introduction

Ubiquitous computing, the Web, and the ever-increasing processing power of computers have made the study of human-computer interaction (HCI) and the design of intelligent human-computer interfaces fields of crucial importance. If we further assume a human-centered approach to interface and systems design, then human preferences for modality of interaction become increasingly important. Moreover, given that humans interact and communicate most easily and effectively by means of natural language, either spoken or written (i.e., the auditory and vocal and the visual modalities), we must recognize and acknowledge the fundamental role that natural language plays in HCI. Indeed, humans generally prefer communicating or interacting with computers in natural language, and computers should therefore be able to understand and synthesize it.

All people, even the illiterate or semiliterate, are empowered to become part of the information society more readily if they are able to use their own languages. Therefore, languages for which no adequate computer processing is being developed run the risk of being marginalized in the global information society, "or even disappearing, together with the cultures they embody, to the detriment of one of humanity's great assets: its cultural diversity"[9].

The discipline that addresses the design and implementation of computational techniques and computer systems that understand and/or synthesize spoken and written natural language is natural-language processing (NLP). Also included in this discipline are speech processing (recognition, understanding, and synthesis), information extraction, handwriting recognition, machine translation, text summarization, and language generation.

In principle, therefore, HCI and NLP are complementary. However, the exploitation and realization of the potential benefits of NLP relative to HCI largely depend on the availability and continued development of increasingly sophisticated techniques and tools for NLP.

In Africa, with its high degree of illiteracy, and where indigenous languages face the constant threat of marginalization, developing indigenous languages at a technological level is critical. Article 17 of the Cultural Charter for Africa of the Organization of African Unity states:

> *"The African States recognize the imperative need to develop African languages which will ensure their cultural advancement and accelerate their economic and social development...."*

It is also recognized that "there is no alternative to the use of the African languages for literacy and for ensuring mass participation in development"[1].

Linguistic Profile of South Africa

South Africa, with a population of 40.5 million people, is in an unusual position. It is a multilingual country that has more national official languages than any other country. Besides English and Afrikaans, the 11 official languages include the indigenous languages Southern Sotho, Northern Sotho, Tswana, Zulu, Xhosa, Swati, Ndebele, Tsonga, and Venda. These indigenous languages, all of which share common linguistic features, belong to the Bantu language family. Bantu consists of more than 400 languages spoken on the southern half of the African continent. Figure 1 breaks down the South African official languages as mother tongues [7].

Although English ranks only fifth (nine percent) as a mother tongue, national leaders, politicians, businesspeople, and officials tend to use English more frequently than any other language. In a national survey on language use and language interaction conducted by the Pan South African Language Board (PanSALB) in 2000, only 22 percent of respondents indicated that they fully understood speeches and statements made in English, and 19 percent indicated that they seldom understood information conveyed in English [12].

This finding emphasizes the basic need for mother-tongue communication and interaction (human-human, as well as human-computer) in South Africa, at both the official and personal levels.

Challenges for Natural-Language Processing in South Africa

Given the reality of 11 official languages, the basic need for communication and interaction in the mother tongue, as well as the relatively high illiteracy rate, human-language technologies need to be developed and put in place.

Developing higher-level applications such as voice access to information systems and machine-aided translation systems is one challenge. Such higher-level applications will play an important role, for instance, in the e-Government Gateway project in South Africa, the purpose of which is delivery of services to citizens through a single service point. The aim of the project is to provide each citizen access to electronic services in his or her preferred mode and language, using both text and/or speech.

A second challenge is developing electronic lexicons, which are essential aids in any language training or automated language interaction. By electronic lexicon we mean a lexicography knowledge base from which diverse types of information can be extracted, usually by means of appropriate user interfaces. Electronic dictionaries could play a central role in improving literacy, especially for users with emerging literacy and little familiarity with dictionaries.

Such lexicons are particularly significant for the indigenous languages of South Africa. In most of these languages looking up a word in a conventional dictionary requires a certain degree of grammatical (morphological) knowledge because words are usually not simply listed by their first letter. This is one of the main reasons why any kind of user-friendly and usable electronic dictionary for the indigenous languages of South Africa is not easily available.

Critical Importance of Computational Morphological Analysis

Meeting the two aforementioned challenges depends on the availability of tools to perform computational morphological analysis. In the case of higher-level applications, computational morphological analysis serves as an enabling technology, in other words, a tech-

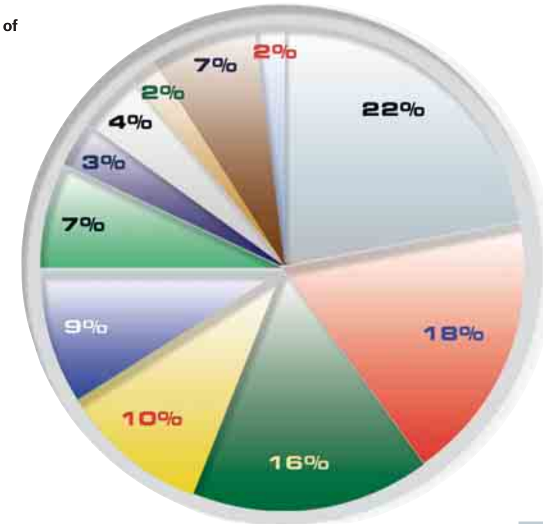

Figure 1. Distribution of speakers of mother tongues in South Africa, by official language (40.5 million speakers).

nology that facilitates the development of further tools and practical applications, including part-of-speech tagging, parsing, text-to-speech systems, information extraction, and machine translation. For electronic dictionaries the computational morphological analyzer provides the missing link between the user who lacks the grammatical knowledge necessary to find a word and the complexity of the dictionary format of the languages belonging to the specific language family.

Computational aids for morphological analysis exist for many European languages, including English, French, German, Spanish, Portuguese, and Italian. Significant work has already been done for Basque, Turkish, Arabic, Finnish, Swedish, Norwegian, Danish, Irish, several Eastern European languages (for example, Hungarian), and Swahili. However, morphological analyzers still need to be developed for the commercially less important languages of the world [9]. Among these languages are those belonging to the Bantu language family, which have not yet received much attention in terms of natural-language processing.

As mentioned earlier, the indigenous languages of South Africa are characterized by their complex morphological structure. Compared with a language such as English, for instance, which has a relatively limited variation of word forms, Bantu languages are quite different. These languages are mainly agglutinating, which means that they extensively use prefixes and suffixes to form words.

In the Bantu languages, the basis for constructing a noun is the root. The root is the constant core element in words or word forms, and the rest is inflection and derivation. Therefore, in a dictionary one would look up the root. Let us look at the complex nature of the monosyllabic noun root *-zi*, meaning “village.” The root can appear in various forms within nouns, for instance:

umuzi “village”
imizi “villages”
emzini “in the village”
umzana “small village”
umuzikazi “large village”

In order to look up any of the foregoing nouns in a dictionary the user needs to know the root of the word. In the noun *umzana*, for instance, it is not at all obvious that the root is identical to that of all the other words, namely *-zi*. Without morphological analysis, identifying the noun root *-zi* in such examples is difficult.

By automating the process of morphological analysis, looking up any word in a language such as Zulu becomes a routine task that requires no specialized grammatical knowledge. In fact, the automatic grammatical (morphological) analysis of a word, as it appears in natural language text, could be included in the electronic lexicon. So, instead of the user’s looking up *umzana* under the noun root *-zi*, the full word *umzana* would yield the following output:

u- preprefix class 3
-mu- basic prefix class 3
-zi noun root “village”
-ana diminutive suffix

In order to automate morphological analysis we need to computationally model two linguistic phenomena, namely the following:

1. *Morphotactics*, or word-formation rules, which means that morphemes that make up words cannot combine at random but are restricted to certain combinations and orders. A morphological analyzer needs to know which combinations of morphemes are valid.
   - *English example:* The morphemes *pity* and *-less* may combine to form the intermediate morphophonemic string *pityless*.
   - *Zulu example:* The morphemes *u-*, *-mu-* and *-ngane* may combine to form the intermediate morphophonemic string *umungane*, meaning "friend."

2. *Morphological alternations*, which means that one and the same morpheme may be realized in different ways depending on the environment in which it occurs. Again, a morphological analyzer needs to recognize the correct form of each morpheme.
   - *English example:* The English alternation rule, stating that *y* is realized as *I* when followed by the string *-less*, modifies *pityless* to the correct form *pitiless*.
   - *Zulu example:* The Zulu alternation rule, stating that *-mu-* is realized as *-m-* when followed by a polysyllabic word root, such as *-ngane*, modifies *umungane* to the correct form *umngane*.

Therefore, in order to automate the morphological analysis of Zulu requires computational techniques and tools for modeling the morphotactics, as well as the morphological alternations.

This brings us to the focus of our work, the development of a computational morphological analyzer for Zulu.

Finite-State Computational Morphology

Since the 1950s the mathematically equivalent notions of regular formal languages, regular expressions, and finite-state networks have been the subject of extensive research and applications including circuit design, pattern matching, and text processing. Two of the main reasons for this attention are their mathematical elegance and the efficient implementation possibilities that they offer [see, for example, 2, 3, 8, 13, 14]. These methods are increasingly used in various fields of NLP and form the basis of the modern approach to computational morphology [see for example 10, 18].

Research in finite-state computational morphology in organizations such as Xerox Research Centre Europe [18] and AT&T Laboratories [5] is based on the fundamental insight that the complexities of word-formation rules as well as morphological alternations can be modeled and implemented extremely efficiently using finite-state networks.

The Xerox finite-state calculus [6] is a powerful, sophisticated, state-of-the-art set of algorithms and programming languages for building finite-state solutions to a variety of problems in natural language processing. The Xerox software tools we used to build a morphological analyzer for the Zulu language are briefly described as follows:

- The purpose of the **lexc** tool, which stands for for lexicon compiler, is to specify the required and essential natural-language lexicon, as well as the morphotactic structure of the words in the lexicon. The resulting finite-state network produced by **lexc** generates morphotactically well-formed, but rather abstract, morphophonemic or lexical strings.
- The purpose of the **xfst** tool is to formulate the alternation rules necessary for mapping the abstract lexical strings into properly spelled surface strings of natural language, using regular expressions. These regular expressions are then also compiled into a finite-state network.
- Finally, the **lexc** and **xfst** finite-state networks are compiled, or composed, into a single network, called a lexical transducer. The lexical transducer contains all the morphological information about the language being analyzed, including derivation, inflection, alternation, compounding, and so forth and constitutes our computational morphological analyzer. In our examples a morphological analyzer for English would map the morpheme sequence *pity* + *-less* to the string *pitiless*, and the Zulu morphological analyzer would map the morpheme sequence *u-*, *-mu-*, and *-ngane* to *umngane*.

It should be emphasized that once the morphotactics and alternation rules of the language have been correctly specified, the morphological analyzer can recognize and analyze only words of which the roots have been explicitly included.

In order to systematically update and extend the root list of the morphological analyzer, the Xerox finite-state tools allow you to build a so-called guesser, a variant of the morphological analyzer that contains all phonologically possible roots [18]. The guesser variant of the morphological analyzer is a particularly useful computational tool for exploring (new) language corpora. By applying the guesser to any corpus as a potential source of new word roots, new (that is, as yet unlisted) word roots are detected, analyzed, and marked for possible inclusion in the current word root list. These new word roots are then scrutinized by the human lexicographer. The suitable and correct word roots are then added to the word root list of the morphological analyzer so that any future occurrence of such a root will be recognized and appropriately analyzed.

In a nutshell, our *ultimate purpose* is to model the morphological structure of Zulu in such a way that *all the Zulu words are included* (generated) and *correctly*

The development of **interfaces** for all the **indigenous languages** of South Africa constitutes a **major challenge** for the future.

analyzed, and that *all character strings* that do *not* represent words in the *real language* are *excluded*.

In other words, the morphological analyzer for Zulu comprises

- *A comprehensive list* of Zulu word roots
- *All the word formation rules* (morphotactics) that apply in the language.
- *All the alternation rules* required to produce well-formed words in the Zulu language.

What does this mean in terms of the dynamic changing nature of natural language? First, it means that the morphological analyzer reflects the *stable part of natural language*, that is, the morphological structure, which includes both the morphotactics and the alternation rules. Second, it reflects the *growth and dynamic nature of natural language*, that is, it contains a comprehensive, current list of word roots that should be systematically extended and enriched as new words are created and come into use.

A number of **project teams** are already **working** on the development of human-**language technologies** in South Africa.

Thus, the availability of a morphological analyzer and a guesser variant of the analyzer, together with a machine-readable lexicon, provide us with the tools for systematically and scientifically exploring the available Zulu text corpora, thereby representing complete, up-to-date lexical information in a format that is accessible to other applications in Zulu NLP.

Conclusion

Our project may be extended in various ways. Future work in natural-language processing includes developing similar tools for other indigenous languages of South Africa and using the tools to build higher-level NLP applications for these languages. Such applications may range from sophisticated high-level machine translation systems to voice-operated educational or commercial systems that can be used by illiterate people, or from applications in education and training to public service (e-governance) and e-commerce applications.

In order to make the lexical information embodied in the computational morphological analyzer accessible to humans as a Zulu electronic dictionary, a novel and versatile human-computer interface needs to be developed. Indeed, the study, design, and development of language and culture-specific lexical and language interfaces for all the indigenous languages of South Africa, and for the whole of Africa, constitute a major challenge for the future.

One exciting development involves the strategic plan for the development of human-language technologies (HLT) in South Africa [17], commissioned by the South African government, which sets out to facilitate the implementation of NLP applications such as those mentioned earlier in order to promote multilingualism and to develop previously marginalized indigenous languages.

A number of project teams are already working in development in the field of HLT in South Africa. The African Speech Technology (AST) project is the first of its kind in South Africa. It concerns a multilingual, telephone based, information retrieval system, supported financially by the Department of Arts, Culture, Science and Technology of the South African government [4]. Other projects include the development of language corpora and spell checkers for the indigenous languages of South Africa [11], the promotion and development of multilingual terminologies [16], and our project on the computational morphological analysis of Zulu [15] and Xhosa, together with the development of machine-readable lexicons for Zulu and Xhosa.

It is our collective vision that these and similar developments will empower the people of South Africa, as well as the rest of Africa, to actively participate in the continent's economy and to become part of the information society by providing optimum use of multilingual information and communication technology with easy access to information in the most natural way—that is, through language and speech.

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Cultures, Literacy, and the Web: Dimensions of Information "Scent"

Marion Walton and Vera Vukovic

Cecil Rhodes wanted to build a railroad from Cape Town to Cairo in order to subjugate the continent. Now we want to build an information super-highway from Cape to Cairo which will liberate the continent [11].

When discussing how people get the "scent" of information on the Web, and thus how best to design for them, we seldom consider the role of literacy. Literacy, in its broadest sense, is not a neat parcel of skills easily packaged and given to someone. Anthropologists have found that literate human societies have evolved a wide range of literacies, each a complex set of practices and beliefs about communication and knowledge associated with particular educational, linguistic, and social contexts [3].

As human-computer interaction (HCI) professionals, we often generalize about the habits associated with reading from the Web, not realizing that the practices we most often describe are those of an elite group of knowledge workers (to which we also belong). Although such workers may have diverse national origins, they come from relatively similar educational backgrounds. Our work with South African students from disadvantaged educational backgrounds identifies some of the challenges in assisting them in joining the ranks of these knowledge workers. Cultural differences make it difficult for these students to make the transition to Web use, although not in the stereotyped notion of ethnic or national cultures. Rather, we need to acknowledge that Web use is situated within distinct cultures of reading and writing.

As South African Minister of Communications, Jay Naidoo imagined information networks as magic pipelines connecting African people to unlimited supplies of liberating information [11]. In this view, literacy is neglected, as it is in many discussions of the educational uses of the Web in developing countries. The notion of the "information superhighway" uses a common but misleading metaphor of communication, which assumes that information is transported from source to receiver in much the same way as a truck transports goods along a highway. Information is *not* a parcel of knowledge that can simply be transferred from sender to receiver. Connectivity is not the only ingredient of a knowledge economy.

Instead, politicians should emphasize that the interpretation and use of information are highly contextualized activities and should be investing in education along with infrastructure. The knowledge work performed on the Web is always associated with a particular, highly specialized domain and requires specific forms of literacy or communicative practices. These practices can include knowledge of the domain and its discourse, academic conventions, written English, and Western visual and user-interface design.

Studies of Web-reading behavior are widely cited, but they do not question whether literacy and schooling may be significant variables influencing the reading patterns observed in usability studies [5, 10, 12, 14]. In developing countries, this information is crucial. We need to recognize that current usability research (and current design practices) may be based on observations of participants from relatively similar, privileged, Western backgrounds. Our goal in this study was to document the skills and practices associated with Web use for a group of South African novice users.

Skilled Web users seem to master a range of specialized reading skills for efficient reading from the

Web [5, 10, 12, 14]. Such practices, and associated assumptions about reading and sources, have probably been built over a lifetime of reading and evaluating large quantities of both printed and online academic and professional material. Skimming and scanning, habits associated with reading from the Web, are strategies acquired by people who are—to use a slightly simplistic catchphrase—"information rich" or are habitually confronted with large amounts of written information to read in a short time. These complex skills have visual, verbal, linguistic, and cultural dimensions.

Similar blind spots can be identified in more theoretical studies. For example, the theory of "information scent" studies the minutiae of information-oriented Web use. Detailed information about individual users' activity on the Web is mined to understand how people adapt to the flow of information in their environment, in the active construction of knowledge [1].

This theory is useful, but it still assumes that information, and its scent, is objectively "out there." Giuseppe Mantovani [7] cautions us that information seekers need particular diagnostic and strategic resources and that community and culture play a role in the construction of information.

Our experiences with South African students have highlighted the sociocultural component of Web use. We have found evidence suggesting a cultural dimension to information scent and information-seeking literacy practices. In using information, students need to move from school-based cultures to academic cultures in order to achieve social mobility. In many South African schools, interactions are oral and in the vernacular; literacy activities are centered on a few scarce and highly valued English-language print resources. In contrast, in predominantly English language-based academic subcultures, a vast range of print and electronic resources must be accessed, skimmed, evaluated, and synthesized.

As students learn to use Web-based resources, they need to master a wide range of new visual conventions. The hierarchical tree from literate Western culture pervades both the interfaces of Web sites and, often—through databases and hierarchical file structures—their underlying organization. Our study revealed the difficulties experienced by certain novice Web users in interpreting tree diagrams and the Web's visual navigational conventions (such as fish-eye views, breadcrumbs, and other implicit trees) that rely on an understanding of such hierarchies [15]. Fish-eye views are hierarchical navigational devices that provide an overview of the major categories of content on the site, giving extra detail about the specific category that the user is currently navigating. Breadcrumbs (named for Hansel and Gretel's trail of breadcrumbs) are used by sites with hierarchically classified directories to indicate the positioning and line of descent of a particular resource within the directory's implicit tree structure. Other implicit trees use various layout devices to encode an implicit hierarchy. The remainder of this paper outlines the study and some of our major findings.

Methodology

The study provides two profiles of 20 novice Web users recruited from a class of students taking an introductory computer literacy course at the University of Cape Town. The first profile involved an initial round of individual interviews, Web searching observations, and visual literacy tests.

Each student completed a set of exercises on visual literacy to investigate their understanding of common interface and navigation conventions on the Web, such as tabs and hierarchical file directory structures. In addition, we investigated:

- Tree diagrams and linear structures
- Breadcrumbs (which trace a path through an implicit hierarchy)
- Implicit navigational hierarchies (hierarchy is implied by layout rather than an explicitly drawn tree)

Students' responses were analyzed both heuristically (by interpreting students' diagrams and comments) and quantitatively. In order to assess their skill at skimming and scanning print materials, students were given a recent newspaper and asked to read it as they normally would. After one minute the newspaper was taken from them, and they were asked to sketch what they remembered of the paper.

Finally, each student generated a list of topics, based on which we asked them to retrieve and interpret information from a Web search engine or directory. We observed students during their first experience of searching the Web, using a combined "think aloud" and tutoring protocol as they attempted to find answers to these self-generated research tasks.

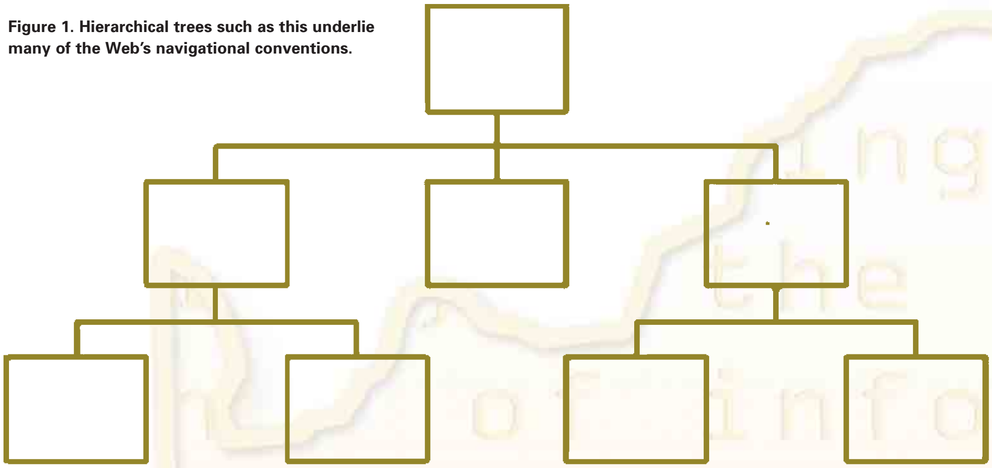
A second profile involved another round of individual interviews and observations of a new set of self-generated Web research tasks. Observations were coded to record all student errors.

As students **learn** to use Web-based **resources**, they need to **master** a wide range of new **visual conventions**.

Findings

At the start of the year, students battled significantly with navigation and were hampered primarily by their limited knowledge of basic conventions of graphical user interfaces (GUI). This limitation formed the largest category of coded errors. For example, extreme novices would not click on hyperlinks, thinking that they were merely underlined for emphasis, and did not know that they should type words into search boxes. They did not realize that they could scroll to see the parts of a Web page that extended beyond the screen, and often did not under-

Figure 1. Hierarchical trees such as this underlie many of the Web's navigational conventions.



stand that pages that seemed blank were simply downloading slowly.

At the end of the year, all students but one had made significant strides in their general competence, confidence, and skill in Web use. None of the characteristic extreme novice user interface errors was visible, and students were generally comfortable in the Web environment. As a whole, their social lives had moved at least partly online, and the majority reported daily use of e-mail, chat, and Web-to-cell phone text messaging (Short Message Service, or SMS). For all but two students, their activities focused on communication and browsing (using the categories defined by Sellen, Murphy, and Shaw [14]). Information gathering, the key activity of knowledge workers, was almost entirely absent. The four students who used Web-based research for assignments had used sources recommended by tutors, and one student who had independently found and used an academically inappropriate Web source was penalized.

Unfamiliar Discourses and Classifications

Studies of hypertext have shown that prior knowledge of a domain helps readers draw inferences and bridge gaps between noncoherent bodies of text [2, 6, 9]. In other words, users' prior knowledge of a domain helps them to pick up the information scent that is needed for them to make the link and to construct their own coherence. Consequently, unfamiliar, domain-specific discourses and classifications can present critical barriers when Web use is unmediated by supportive communities of practice.

The novice Web users of our study experienced serious and complex problems when using the Web for academic purposes but were more at their ease when using it for everyday reasons (when they were more familiar with the discourses and classificational systems). These problems go beyond the well-documented sense of disorientation experienced by many users when navigating a hypertext. The issues that need to be considered here include:

- Familiarity with Web-specific visual conventions
- Experience in speed-reading practices
- Understanding the concept, scope, and purpose of a Web search
- Ability to make sense of incoherent hypertextual artifacts such as search results
- Barriers presented by the English language and specialized discourses
- Alien classification schemas
- Limited knowledge of academic domains

Visual Information Hierarchies

Visual exercises suggested possible cultural dimensions of the interpretation of common visual navigational conventions on the Web. For the users we studied, the problem was not the relatively superficial one of not recognizing icons such as tabbed files, folders, mailboxes, or trashcans (as discussed by Marcus [8]). Students were able to use visual metaphors such as tabs, despite their having encountered them only in their computer literacy course. More difficult challenges involved interpreting the meaning of hierarchical information structures.

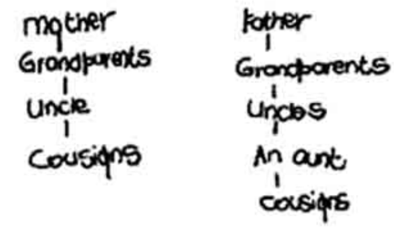


Figure 2. Khanyisile's "family tree."

As suggested by Kress and van Leeuwen [4], hierarchical classificational tree diagrams (Figure 1) are a culture-specific visual form. People need to understand the associations and hierarchies that implicitly connect the terms in the structure. For example, the conventional Western family tree structures families according to generations, with a patrilineal line of descent. This tree (grandparents, parents, children) is a basic metaphor underlying many of the logical structures we use to structure information.

Several student diagrams suggested the cultural specificity of this form. For example, Figure 2 is an example of the unconventional structure that one of the students, Khanyisile (all names have been changed to protect the privacy of the participants), produced when asked to draw a family tree. Interpretation is difficult, as in this case, particularly when the diagrams diverge from the Western conventions. However, she seemed to visualize her family as two lineages, one maternal and one paternal. Other students' diagrams seem to be structured around lines of gender or familial power. This set of diagrams suggests the diverse ways in which human societies organize and model the world, and these are not always identical to conventional Western structures.

Screen shots of implicit tree structures from domains relatively familiar to students (such as sport and music) were chosen as examples to determine the students' understanding of the various structures. Linear conventions (such as hypertext "next") were understood by three-quarters of the group. In contrast, the visual conventions expressing tree structures implicitly through layout (such as fish-eye view navigational devices) were understood by only a third of the students, and only a tenth of the students were able to interpret breadcrumbs.

Print Reading Practices and Source Awareness

A quarter of the students were observed to read Web sites line by line, often moving the mouse pointer slowly and painstakingly along lines of text on the screen. Their sketches of the front page of a newspaper suggest that this might be their mode of reading print as well. For example, another student's sketch suggested a possible linear reading pattern, since it focused on the top "kickers" rather than main headlines or pictures.

The artificial nature of the exercise and the need to remember and draw the page mean that this information is by no means conclusive evidence. Nonetheless, in combination with our observations of "mouse reading," the information does suggest the possibility of reading patterns different from those of elite knowledge workers. More conclusive and detailed evidence for linear reading patterns, however, would require the use of eye-tracking equipment.

Interestingly, only four students were able to correctly recall the name of the newspaper. Several students who included a newspaper name included an incorrect name, indicating that they did not consider the name of the newspaper important enough to consciously register it. This contrasts strongly with the intense source-awareness that characterizes the knowledge workers discussed by Sellen, Murphy, and Shaw [14] and the participants in Nielsen's Web usability study [12]. A similar lack of awareness of sources bedeviled most of the Web searches we observed. Inappropriate sources were selected, and many students used sources from the United States or Europe, thinking that they referred to South Africa. Source awareness is a key difference between academic and university literacy practices, and students making the transition to academic culture need to consider the source of information at the same time as its content and to be alert to the subtle signs by which we identify sources on the Web.

Scope and Concept of Web Searches

Understanding the scope and concept of Web searches is difficult for someone with no sense of a database and little sense of the vast number of resources indexed in search engines. Students came from environments where information is a scarce commodity, and consequently, the most common problem we documented was the use of inappropriately general queries—even after the formulation of more specific search questions. For example, a student formulated the need to search for "more about African jazz," but translated this into the query "music." When interpreting search results, students missed potentially relevant sources because their goal in the search was to find a brief "point-form" summary similar to that provided by teachers at school, rather than the academic goal of synthesizing information from a wide range of sources. As Yusuf Sayed [13] points out, many South African students struggle with research because they "do not realize that it is unlikely that there [is] a single source containing all the answers."

Additionally, students seemed to assume that the computer understood and remembered their intentions and previous actions. For example, using a South African Web directory called Max, a student named Tumi attempted to locate the South African constitution. She misinterpreted Max's interface, which presents its hierarchical collection of topics visually, as a partial tree diagram. In the Law section of the directory, she chose Cases, rather than Constitutional Law, explaining that she was looking for "case studies." When questioned, she explained her logic: She imagined that all subsections of the tree had been generated from her previous search on the death penalty.

Breadcrumbs and Alien Categorization Schemes

When anthropologists study other cultures, they pay careful attention to classification schemes. The students in our study were often overwhelmed by the classification schemes used on both South African and international sites, and categorization was the third most frequent cause of error for the students. Even general Web directories such as Yahoo! and Google inherit academic classificational schemes and mingle these with new categorizations structured around the habits, interests, and beliefs of moneyed, usually Western users. To complicate matters further, the implicit hierarchy in the omnipresent breadcrumbs structuring convention was not clear to any of the students.

Searching for current South African exchange rates in the Max directory, Musonda, a student, read through the categories carefully. Initially unsure whether to choose the category Business and Finance or Industry and Trade, he first selected Business and Finance and then, somewhat despairingly, resorted to the catchall subcategory "Other Finance." Abandoning the site hierarchy, he tried the search engine, which returned several matches, including **Travel and Tourism > Currency**.

He ignored this link and followed a red herring. Max assumes that a user would be interested in currency primarily because of international travel, an activity that does not register strongly on Musonda's cultural radar. When I pointed out the link to him, he thought a bit before making the connection: "When you are traveling, you worry about currency." Musonda's facility with English-Zulu translation here needed to incorporate a more difficult translation—translating between his search goals and those of the Web's paradigmatic, wealthy, middle-class, Western user.

Conclusion

Some of the challenges we have identified can be addressed through training and through Web designs that build maximal coherence, through the use of microcontent and good metadata, and through building sites that do not depend exclusively on hierarchical, tree-based conventions. However, some of the more crucial challenges are not likely to be solved at the interface level. We may weave information scent carefully into our Web designs, but in the last analysis, the scent is in the "nose" of the user. In developing contexts, the user's goals and practices may be vastly different from our assumptions, and they may not be able to crack the many codes by which we have encoded the scent.

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ACKNOWLEDGMENTS

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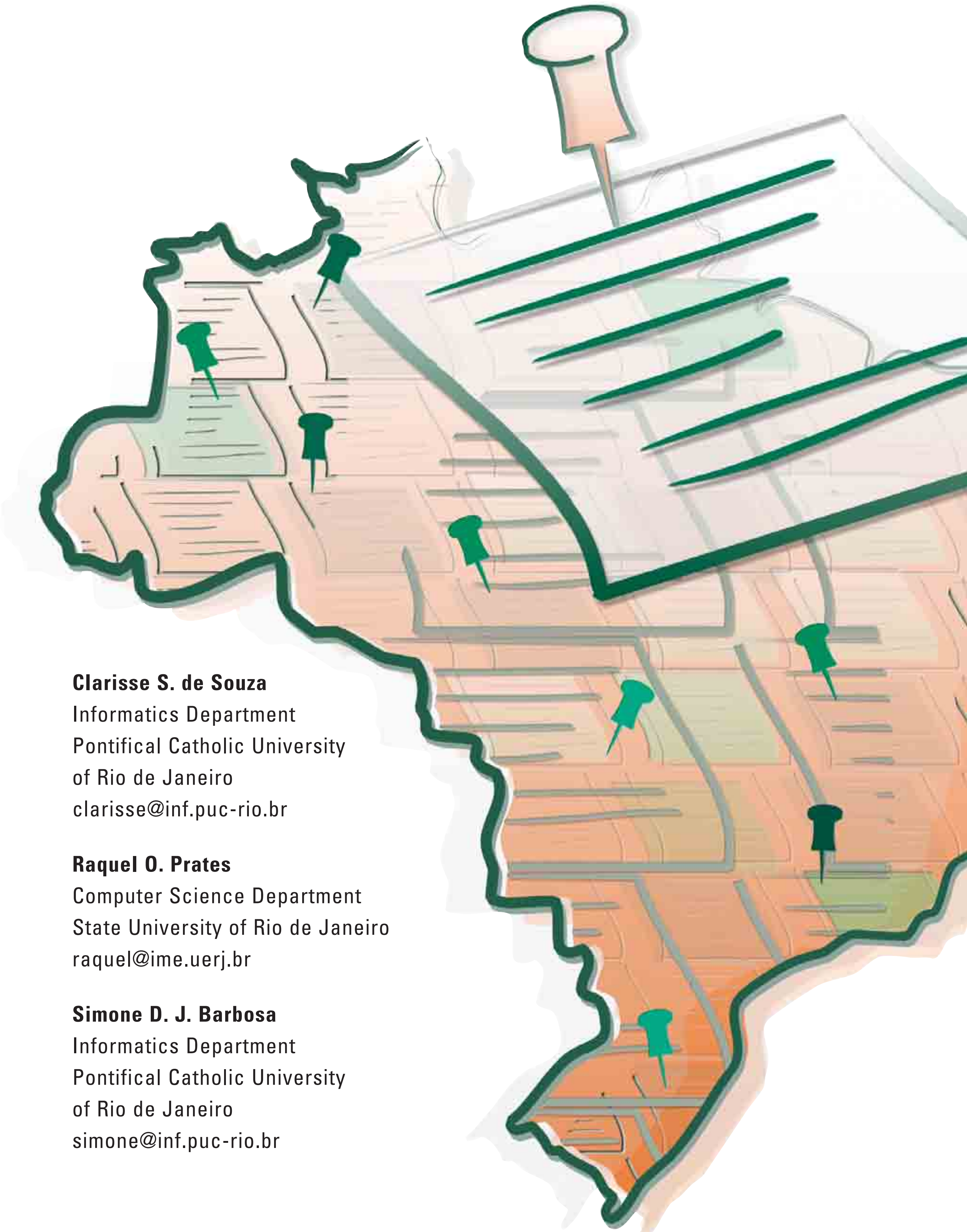
Adopting Information Technology as a First Step in Design

Lessons Learned from Working with Brazilian Social Volunteers



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When the Information Society program (SocInfo [5]) was launched in December 1999, one challenge the Brazilian government posed to itself was to use information technology (IT) to foster wider social inclusion in Brazil. The other was to enable the Brazilian IT industry to compete in a globalized world in which digital presence has a high economic value. "Bridging the digital divide" naturally became a hot topic for technical and political debate, but a sharp image of which factors are involved in this effort has not yet been formed. Government initiatives have typically concentrated on distributing computers to schools and community centers, and connecting them to the Internet. One obvious reason for emphasizing the physical aspects of IT is that they are more easily and objectively measured. Also, achieving immediate tangible impact is in this context an important political goal.

Much less attention has been paid, however, to what runs on these computers, or to which programs and applications will actually improve the lives of users, their families, and their communities. As a society, we tend to feel that giving people more information and education will improve their lives. But we know little beyond that. In particular, we don't exactly know what kind of information is the most important, much less the form in which we should convey it.

Determining how to proceed requires knowledge and skills in addition to those of IT professionals. We must turn to the social sciences of sociology, anthropology, psychology, education, linguistics, and a number of other disciplines that have traditionally not worked together in Brazil on computer applications. When these disciplines have examined technology, their contribution has typically been more analytical, focusing on what *has been* the effect of technology on studied groups, and not what kind of intervention should be made to change a specific state of affairs. The SocInfo initiative requires a design and engineering perspective that these disciplines haven't traditionally adopted in Brazil. One of the few initiatives of SocInfo that focuses *not* on promoting technology infrastructure but on identifying which applications will help bridge the digital divide is the Digital Contents sub-program. In 2001, government agencies called for proposals and selected 45 of nearly 400 projects. The Oré Project, carried out at the Semiotic Engineering Research Group (SERG), in the Informatics Department of Rio de Janeiro Catholic University, was among the projects selected. The long-range target of Oré [7]—an acronym for Organize, Reflect, Evolve, as well as a native Brazilian word that means "we, our(s), with us"—is to widen the participation of Brazilian civil society in social volunteering initiatives. According to Brazilian government officials [10], a vast number of human resources ready to do volunteer work are wasted for lack of organizational infrastructure. The expected contribution of Oré lies precisely in using IT to help volunteer organizations become functional and effective, by providing them with a suite of groupware applications.

Oré Project

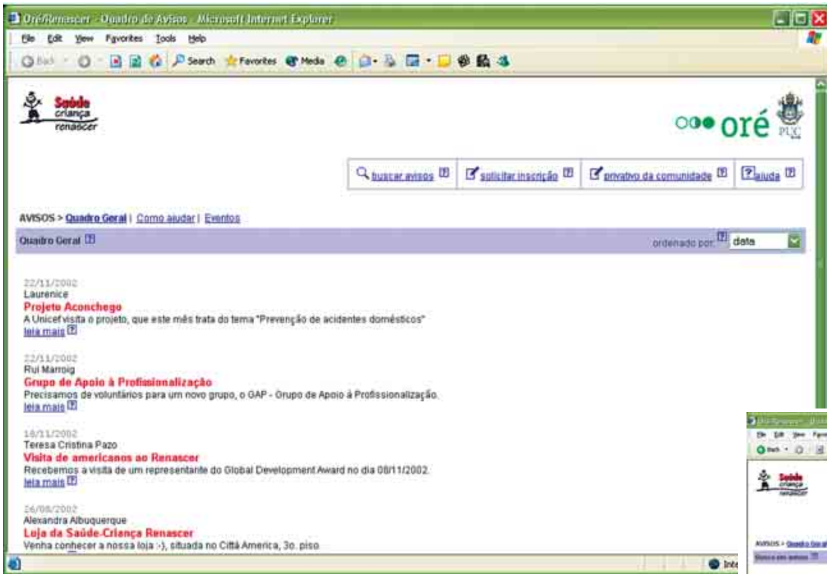
When the project started in January 2002, our first step was to look for partners. One of them was the National Research Network, which has been active in the nationwide development of Internet technology [11]. The other was Associação Saúde-Criança RENASCER (ASCR; Health-Child Rebirth Association), an organization that provides emergency assistance to disenfranchised hospitalized children and their families [9]. ASCR is one of the most successful and respectable nongovernmental organizations (NGO) of its kind in Rio, operating with approximately 150 people, 80 percent of whom are volunteers.

At ASCR, our first step was to identify if and how technology could help the organization. In order to discover ASCR's main goals in, difficulties with, and possible enhancements from the use of technology, we had several meetings with the director, general manager, and an employee of ASCR who was developing a database for the NGO. These meetings suggested that key challenges for the organization were the difficulty of coordinating the work of its many volunteers, providing sponsors with data about projects, and avoiding duplication of information.

At first, these findings led us to think that we should concentrate on adapting existing groupware and workflow applications to fit ASCR's needs. We thought we could leverage the experience that SERG already had in developing groupware and workflow applications for large Brazilian companies. However, as we learned more about the particular characteristics of the volunteer organization and its volunteers, we were forced to change these assumptions.

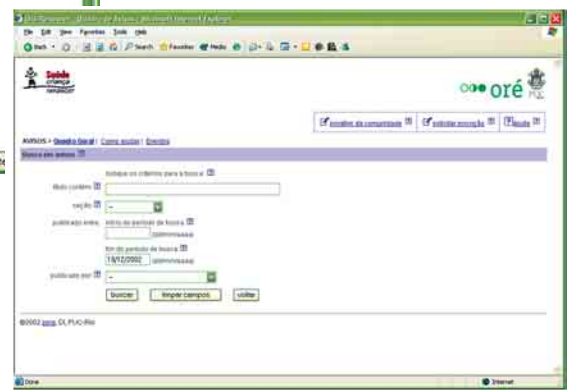
Getting to Know Our Users

Even if a system was intended to meet the needs of ASCR's managers and professional staff, volunteers would have to interact with it for it to be successful, so we knew that we would need to put a great deal of effort into understanding these "end users." Volunteers constitute a challenging type of users, because they come from a wide variety of cultural backgrounds, they have a constant need to adapt planning and execution of tasks to the available resources (human and other), and finally because their main motivation comes from their own satisfaction in doing their work, as opposed to their salary or careers. We knew we would have to understand factors like these and take them into account if we wanted them to be motivated to interact with a new computer system. In order to learn more about our future users' particular needs, difficulties, and priorities, we decided to use the Underlying Discourse Unveiling Method (UDUM), originally developed in clinical psychology [1, 6]. UDUM uses open-ended interviews that are sensitive to what people have to say freely. It focuses on grasping and analyzing hidden or implicit fears, desires, motivations, aspirations, conflicts, and other deep feelings experienced by individuals. The method was partic-



1a

Figure 1. Sample pages from an Oré prototype: (a) viewing announcements and (b) search form.



1b

ularly well suited for the task, given the highly subjective values and attitudes underlying the behavior of individuals who *volunteer* for a cause.

We looked for ASCR members who already used computers to some degree in their volunteer work, such as by exchanging e-mails. Our broad understanding of *computer literacy* was "having some experience with computers," that is, not necessarily having any training but regularly using the computer for personal or professional activities. We started by interviewing 10 people, whose ages ranged from late 30s to early 60s. The interview addressed four major topics: (1) the interviewees' profile (how they described themselves), (2) their experience with computers, (3) the tasks they performed at ASCR, and (4) their dreams or fears about the introduction of information technology at ASCR.

Analysis of the interviews [1] suggested some characteristics of ASCR that potentially extend to organizations of social volunteers (OSV) in general. We learned that most of our interviewees had offered to work for ASCR in order to fill up their idle time. Many were senior citizens who had retired from their primary jobs. Volunteers are largely free to act as they wish, and they enjoy being able to do so. They often applied their experience and knowledge to their activities at ASCR. They are proud of the work they do—and proud of ASCR. We also found that most ASCR employees and volunteers appear to be tentative toward computers and, in some cases, downright averse.

We learned many things about how coordination and communication are accomplished at ASCR without a dedicated software application. The volunteers' tasks are mainly autonomous, and tasks performed by other volunteers are not explicitly coordinated at a high level. Because tasks are independent and volunteers work only a few days a week for the organization, they do not know many of their fellow volunteers in person. Thus, volunteers who perform the same tasks may not know each other or how they choose to accomplish their tasks. Another complicating factor is that ASCR's functions are distributed throughout three buildings—a hospital, ASCR's headquarters, and a training facility. One volunteer described the communication problem among members of ASCR as, "People work in different ASCRs."

Nevertheless, many social and informal communication and coordination channels do exist. Volunteers who know each other often spontaneously meet during coffee breaks or outside their time at

ASCR. The organization tries to have better communication channels with all members through a monthly general meeting, through their printed bulletin, and by posting announcements about organizational events and news at different locations. However, volunteers reported never having known that the meeting was open for all volunteers, not learning about events in time to attend, and not knowing much about what was going on with the organization.

We spotted some striking contrasts between these potential users and the kinds of users we had worked with previously. First, at ASCR, and possibly at most OSVs, volunteers are assigned to various activities based on personal interest and availability, and they can have wide latitude in deciding how to perform their work. And because most volunteers work occasionally or part-time, their tasks are typically performed by different people in different ways. This contrasts with the standardization and work flow of quality control present in many companies, where there is more freedom to institute top-down, technology-related policies based on generally perceived productivity gains. Thus, if IT is expected to support work at OSVs and to be spontaneously adopted by all volunteers, it must be flexible enough to accommodate extremely different work practices and subjective motivations. Any mistake in introducing IT in such environments may discourage volunteers and cause severe losses for the organizations. At a minimum, any system oriented only toward the needs of the professional staff would simply not be used.

Therefore, our first lesson learned was that a successful strategy for introducing IT in a community of volunteers should be a prime goal of Oré, overriding all other initial goals. Our thinking about this was consistent with the adopter-centered process approach [12]. Software that meets the managers' more ambitious organizational goals would be successful only if the volunteers interacted with it. For the volunteers to use the software, it would have to not only meet their needs and be easy for them to use, but also be inviting for them to adopt, given such things as the dynamics of their work and their attitudes about technology. An application that met these requirements was likely to be much more modest in its goals and limited in its functionality than the groupware application we were envisioning initially, but it would have to be the starting point. Only then, we thought, could we actually ask them about the kind of technology that will potentially improve their work practices, support OSV in administering resources and opportunities relative to existing social challenges, and ultimately contribute to promoting this kind of volunteerism in Brazil.

Instead of, therefore, immediately developing full-fledged groupware applications, we decided to begin by developing a more modest application technology that the volunteers could use spontaneously as opposed to through a mandatory, technologically mediated process in the organization. To stimulate its use, we chose to focus on the communication problem our informants had reported, because it would allow for a simple solution, and all members, as well as the organization, could benefit from it. Specifically, we decided to

2a

Figure 2. Sample pages of the second prototype: (a) announcement display and (b) search form.

2b

build a prototype bulletin board application on which ASCR community members could read and post news that is relevant or interesting for their activities.

Building the First Prototype

We assumed that a bulletin board was a technologically simple application that could be easily introduced with minimal or no training to this community. Our first prototype was custom-designed for ASCR in the Web environment. We incorporated familiar signs of ASCR's location, practices, officials and employees, and so on. We emphasized online help in all Oré prototypes and applications, given the purpose of introducing technology. To achieve this end, we followed a model-based approach for both application design [2] and help system design. We assumed that using presentation patterns and a bulletin board function frequently found on the Web might make it easier for infrequent users to learn and use the application, given the possibility to transfer knowledge from other applications to ours, and vice versa. Thus, for example, in our prototype, nonauthenticated users can only browse and search public announcements, whereas authenticated users can post and edit announcements in addition to browsing and searching. Announcements can be classified into sections, which are viewed in a single page. A navigation bar allows users to browse all other sections in the bulletin board. We have chosen to design multiple entry points for the help system, close to the contextual signs to which they applied. Figure 1a shows the Web page for visualizing announcements in a section, and Figure 1b shows the Web page for searching. The latter contains a search form of the type commonly found on Web pages.

Learning from the Exploratory Prototype Evaluation

Having developed this prototype, we next set out to understand how users perceived it. When preparing the prototype for initial exploratory evaluation, we loaded both factual and fictional (although plausible) announcements in our database. We then performed some exploratory communicability evaluation tests [8] with six members of ASCR. We wanted to learn how well our solution would be understood and used by the members of ASCR, and about unanticipated challenges we might face. Among the six participants were two who had been interviewed during the user studies phase. We included users with varying levels of computer literacy (for instance, one used ICQ to communicate with other family members) and belonging to different age groups (early 30s to late 60s). The tasks involved finding specific announcements and creating and editing announcements.

Three of the six participants were able to perform all the tasks, and their tests pointed out only some minor usability problems in the interface. The other three, however, had a lot of difficulties in completing tasks, including some that were quite interesting to us. For example, when looking for specific announcements in the bulletin board, we expected users to try to match the textual content they wanted the announcement to contain. As is the case with most search forms, the content of the fields is combined in an "AND" search expression. But instead of adding up words to *refine* the search, two participants tried to add up words to *increase the chances* that a term not found in a first trial would be found in a second or third attempt. They did not realize that rather than broadening their search, they were increasingly constraining it. Another interesting observation occurred when participants were asked to change some data on an announcement they had previously created. Our goal was to observe whether they understood how to edit announcements. But, to our surprise, two of our six participants didn't even think of editing it. They simply created another announcement that rectified the previous one. This suggested to us that these participants did not grasp the life cycle of an announcement on an electronic bulletin board. They didn't understand that an announcement is not like a message that has been mailed to people, which, if it contains an error, needs to be followed by a separate message with a correction.

Redesign

On the basis of our findings, we redesigned a set of mock-up Web pages, in an attempt to further simplify the bulletin board interface. For example, we decided to include more instructional information directly into the user-interface screens: contextualized tips and brief instructions within the working space, as well as more explicit instructions in visually distinct areas. On the search page, we decided to move from structured search fields corresponding to the actual database model to unstructured fields in which users may type in any word to appear in any of the database fields. We also made explicit two alternative search options: to search for announcements in which at least one of or all of the typed-in words appear. Figures 2a and 2b show mockups of announcement visualization and search form pages, respectively, for our second prototype.

We discussed the proposed changes with four of our prospective users. Two of them, the general manager and the database designer, had been participants in our tests and experienced some of the difficulties reported in this paper. They had also participated in the first initial definition of the technology to be offered. We focused the discussion on the expected social impacts of each of the prototypes and the time necessary for having them available to ASCR.

Conclusions

In the Oré project we followed a user-centered approach.

A key lesson has been the amount of effort we should dedicate to a strategy for technology adoption. The introduction of technology and its impact in the organization were previously considered a challenge for groupware designers [4]. However, in the Oré project, this introduction is different from changing users' work practice in commercial or industrial organizations, because the gains in the quality of processes and individual productivity are not the main motivation of our community of volunteers. We must gently introduce them to computers, in such a way that they will be motivated to freely adopt the technology (and thus, eventually, help ASCR achieve its organizational goals).

Our work with this community of social volunteers requires skills and knowledge that go beyond user-centered design as practiced for improving work. Addressing subtle and important psychological and cultural factors requires concerted support from researchers and professionals from many other disciplines that typically have not been involved with studying technology from this perspective, particularly psychology, sociology, and anthropology. We believe the lessons learned here can be useful to people working with OSVs worldwide, as well as to those working toward bridging the digital divide anywhere.

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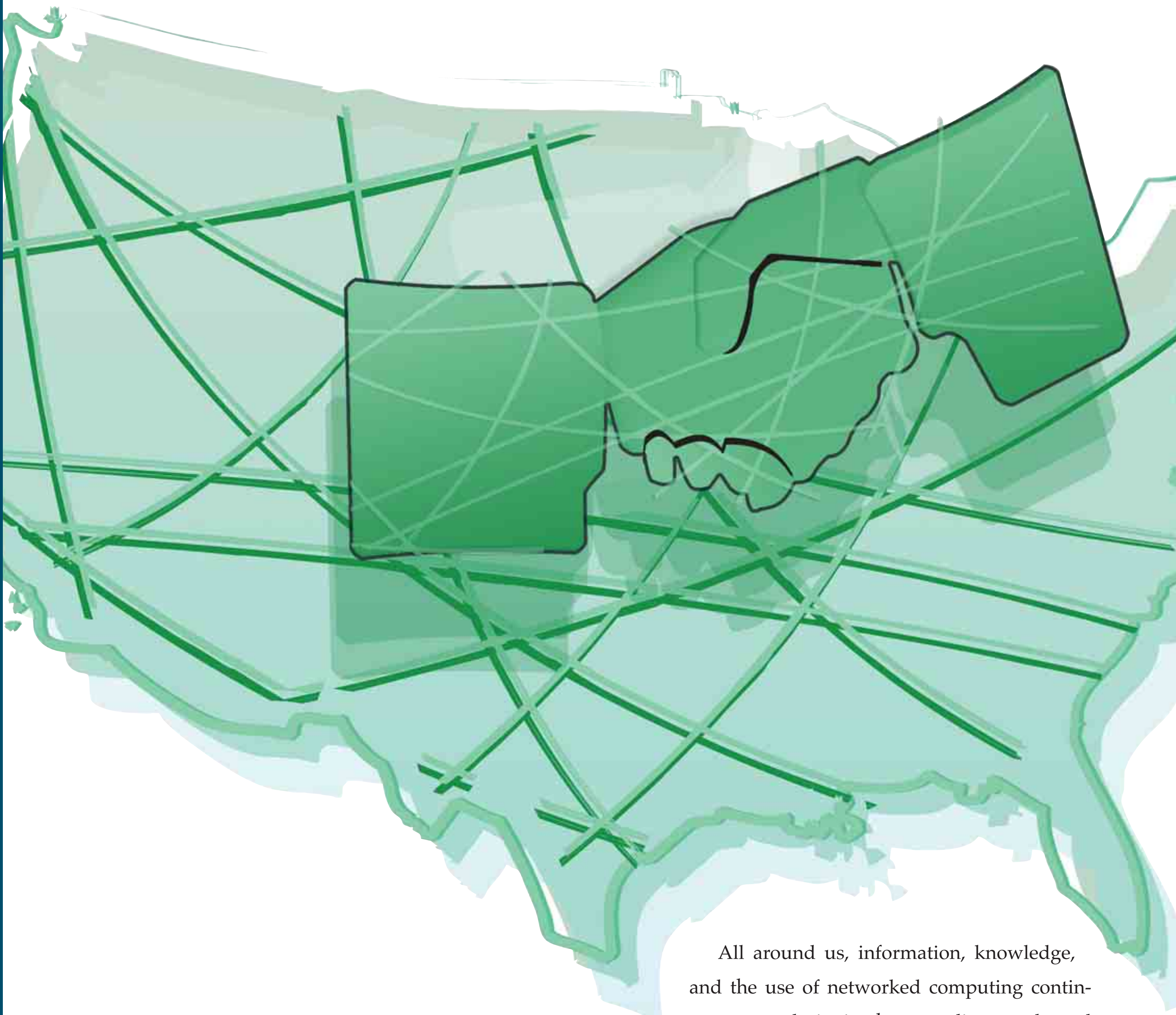

HCI in the So-Called Developing World: What's in it for Everyone

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All around us, information, knowledge, and the use of networked computing continues to revolutionize how we live, work, and play. Although this perspective is obvious to many of us and in danger of becoming hackneyed, important structural changes are indeed occurring. Driven by social, political, economic, and technological factors, these profound changes are having a significant impact on the organization of global society ([3], among others).

This article explores briefly the implications of some of these changes. It argues that human-computer interaction (HCI) and user-centered design (UCD) principles are critical to ensuring that both developed and developing countries are able to meet the challenges posed by these changes and harness the opportunities of globalization and the emergence of an information society.

Globalization and the Information Society

Some scholars refer to this historically significant transformation as the emergence of a global information or knowledge society [22] and argue that it represents a fundamental shift in the underlying techno-economic paradigm of society [13-15, 21]. Collectively, these changes are often taken as indicators of continued and ongoing "globalization."

However, far too many people only see this term in reference to the interdependence of global markets and the deepening integration of global finance. Although this perspective on globalization, often called "economic" globalization, is valid, numerous other complex interactions at sociological, technological, cultural, and political levels are defining this historic period. Our conception of globalization is much more expansive, including social, political, economic, technological, and cultural implications.

Much of this transformation is facilitated by the increased use and development of global information and communications networks, intangible products and services, and new organizational forms. Even with the meltdown in the DotCom sector, structural transformation is still occurring in underlying business processes and models, stimulating the development of a global information economy.

Globally Distributed Knowledge Work

Through the use of these global information and communications networks, companies are able to take part in globally disarticulated production and distribution processes. This means that the various components of their production and distribution processes no longer must be geographically collocated. In taking advantage of this "world factory" model [29], companies can locate their research and development facilities almost anywhere in the world, and engineers can collaborate across time zones, institutions, and national boundaries to develop the next generation of products and services. Furthermore, production facilities can be located in multiple cities, sharing resources, equipment, and personnel.

Perhaps most important among these developments in the global economy is the increasing importance of distributed knowledge work. Distributed knowledge work refers to economic activities that produce intangible goods and services—that is, digital and capable of being both developed and distributed around the world using these very same information and communications networks without all or any of the participants being geographically collocated. Examples of such services could include financial services, consulting, research, software production, distance learning, and telemedicine. Distributed knowledge work is also essential for managing and coordinating disarticulated production of all kinds of products.

The emergence of these new business models is based, in part, on the continued rapid development of a global information infrastructure (GII) and Web-based collaboration tools that make it easier for groups of people to deepen their levels of cooperation with remote and distributed participants. Internationally, these forms of distributed knowledge work are covered by the General Agreement on Trade in Services (GATS), an agreement negotiated and implemented within the World Trade Organization (WTO). More than 140 countries (both developed and developing) are signatories to GATS, which promotes development of the global trade in services, now making up 64 percent of the global economy [35]. Already, global trade in services accounts for 60 to 70 percent of production and employment in developed countries, and has been the fastest growing component of world trade for the last 15 years. This focus on distributed knowledge work is increasing after the events of September 11, 2001, and with the worsening of the climate for international travel.

Developed and So-Called "Developing" Countries

In this period of globalization, existing concepts of developed and developing countries are being challenged. Socioeconomic development in this new period requires of countries, organizations, and individuals an increasingly complex collection of skills, competencies, strategies, and knowledge [7], Reich. Some scholars argue that these issues may lead to a new conceptual division in the world, beyond the "developed" and "developing" world distinction that has dominated since the end of colonialism (and certainly beyond the outdated "first," "second," and "third" world distinctions that were the hallmark of the Cold War). If we follow the suggestion of Attali [1], we should now recognize that there are potential "winners and losers" in this coming world order in both "developed" and "developing" countries. What determines these winners and losers is not necessarily whether someone lives in one of the countries represented by the Organization for Economic Cooperation and Development (OECD)—the OECD is often used by economists as a proxy for developed countries and the Group of Eight (G8) industrialized countries (G8) as an even narrower grouping of developed countries, with all others assumed to be the developing countries.

In this period of globalization, existing concepts of developed and developing countries are being challenged.

According to the perspective of Attali and others, what determines these winners and losers in this historic period is not whether we live in the G8 or OECD countries, but whether we have the knowledge skills and abilities to add value to this new kind of global information economy and society. Some scholars call this distinction the "fast" and the "slow," arguing that people on both sides of this fast and slow divide exist in both the developed and developing countries. Specifically, there are people living in, say, Ann Arbor, Michigan, who have these kinds of "fast" skills, but these skills can also be found among people living in Johannesburg, Dakar, São Paulo, Bangalore, or Kuala Lumpur. In contrast, numerous people also live in each of these cities who do not have such skills and may be classified under this scheme as "slow."

Although I don't really like the fast/slow metaphor, the new perspective that it promotes has merit. It forces us to realize that these new networks provide opportunities for the fast to consolidate their power around the world and for the so-called "slow"—those who do not have the knowledge, skills, and abilities—to exist in both developed and developing countries.

What is at Stake?

Developing Countries

For so-called developing countries, this transformation is profoundly significant. It represents a challenge to the national development strategies of developing countries while presenting an historic opportunity to harness these new technologies and organizational practices. Developing countries have an opportunity to lessen the impact on their economies of geographical distance and to participate more fully in the global information economy and society through distributed knowledge work and the global trade in services.

These opportunities and challenges are magnified reality, exacerbated by the transformation in the global economy. Given the reduction in international aid, it is even more important for developing countries to now be able to participate in global trade. Luis Fernando Jaramillo, former chair of the Group of 77, representing the world's poorest countries within the United Nations system, has argued that, "Neither official development assistance, nor technical assistance, nor credit resource flows, nor any other aspect of international cooperation match the paramount importance and determinant nature that trade has for the developing world."

However, at the same time, the fundamental nature of global trade is changing drastically. Old strategies for socioeconomic development will no longer work in this period. Even further, the nature of the global economy is becoming increasingly integrated and interdependent through the use of the GII and the emergence of a global information and knowledge-oriented economy. One aspect of this change is the increasing importance of the global trade in services, represented in our community in studies of distributed knowledge work.

Even for small, medium, and micro-sized enterprises (SMMEs) in developing countries, opportunities exist to contribute to globally distributed value chains in the information economy (for instance, through participation in global virtual production teams, scientific collaboratories, and distance learning). Nonetheless, at present, developing countries are insufficiently involved in these activities. In order to increase the successful participation of developing countries in the global trade in services, it is important for us to better understand the social and technical factors that support distributed knowledge work between developed and developing countries. It is also important for us to understand the implications for education and learning, especially as we develop distance-independent learning programs to help prepare our students—in both developed and developing countries—to participate in these kinds or research and production activities.

Developed Countries

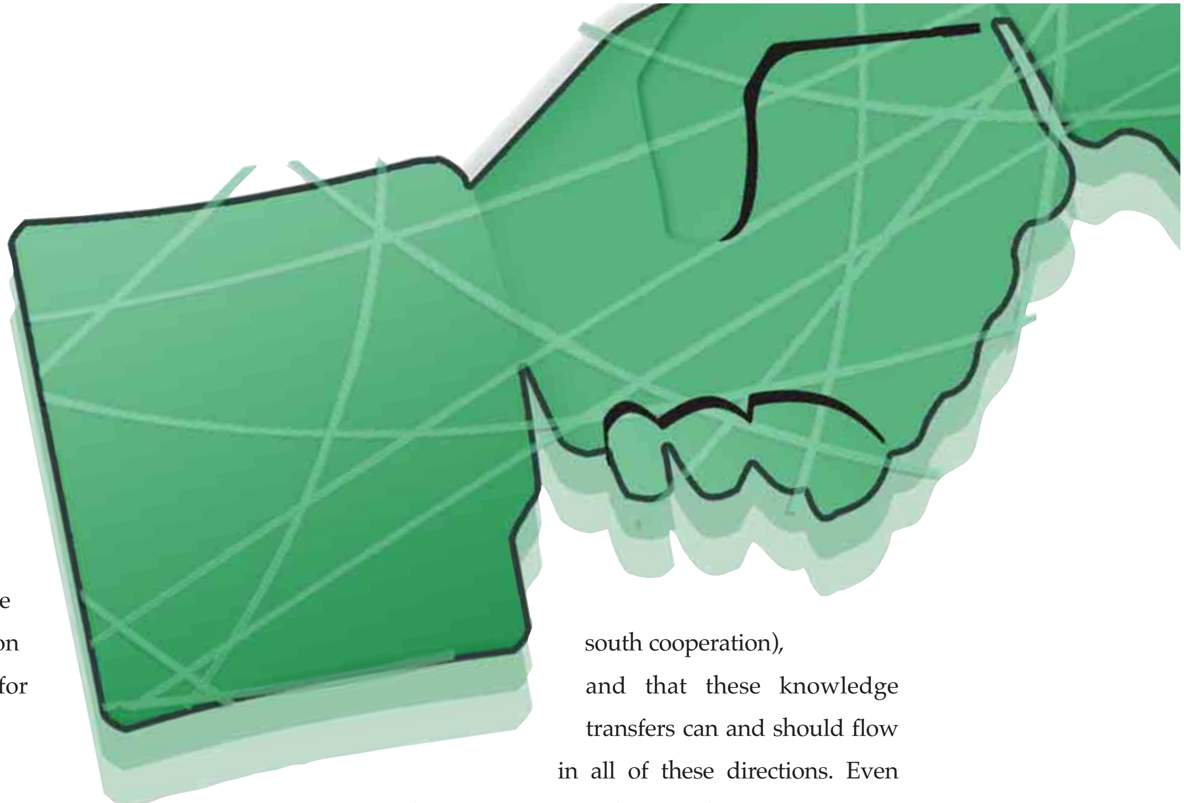
In developed countries, the socioeconomic implications are no less important. Being able to organize their work processes globally, tapping into the knowledge base that exists around the world of local practices, customs, languages, and norms, will have a tremendous impact. Perhaps more important, the ability to develop products and services that are relevant to the multiple cultural perspectives around the world and sensitive to their needs may determine the success of these products and services in exploiting these new markets.

These developments will have two important consequences. Stakeholders in the developed world, meaning the OECD countries, will benefit from socioeconomic development in the developing world in a number of ways, from developing new trading partners and collaborators to lessening the need for development aid, to contributing to a more just global social order. Even further, the so-called developing world will have new opportunities for development in this historical period of globalization and the information society, particularly through distributed knowledge work. However, in order to take advantage of these opportunities and to bring the benefits of globalization and the information society to as many of the world's citizens as possible, the methods and techniques of HCI are important for a number of reasons.

User-Centered Design: The Global Imperative?

Information technology products and services need global markets, not just local ones. In order to support this need, the new mechanisms governing the global trading system reflect a guiding principle called "reciprocal market access." This principle means that while developed countries will certainly explore market opportunities in the developing world, developing countries have just as much right and *de jure* access to the markets of the developed world for their products and services, including technology products and information services. HCI has a major role to play in making sure that these products and services work for their users.

Some scholars have argued that many of the current metaphors used in computing are culturally biased. Culture has an impact on the way in which people use and experience these technologies [17, 23]. Thus, neglecting cultural factors will create significant barriers to global success. Expanding HCI approaches can help to address these limitations. For example, user-centered design principles can help to ensure that the needs and cultural perspectives of the developing countries are sufficiently taken into consideration. This approach can help us to design interfaces that are culturally relevant, taking into consideration such issues as language, history, religion, and the way people think. Products and services taking UCD principles into account will most likely find broader global markets than those that do not. But beyond this, the global economy will require information technology *per se* to work for global users, because this technology provides the infrastructure that allows the communication and coordination necessary for disarticulated production.



Examples of Opportunities for the HCI Community

Building Human Capacity for All: Computer-Supported Collaborative Learning

As discussed earlier, in this historical period the knowledge, skills, and abilities required for socioeconomic development are changing rapidly and dramatically and include the need to better understand how to manipulate symbolic knowledge and to work in global virtual teams [7, 23]. This need for human capacity development exists in both developed and developing countries as well.

Together with a number of colleagues, I have been pursuing these themes in work on computer-supported collaborative learning (CSCL) to support geographically distributed human capacity development. Specifically, we have been involved in projects linking us with southern Africa in education [8-10] and other scientific domains [31]. This approach should not be construed in a paternalistic fashion or pursued in such a way that continues colonial or neocolonial practices. Quite the contrary, we should realize that there are important intellectual contributions to be made in many directions (for example, between developed and developing countries, and between developing countries themselves, often referred to as north-south and south-south cooperation), and that these knowledge transfers can and should flow in all of these directions. Even further, in countries such as South Africa, concerted efforts must be made to ensure that more African scholars are brought into the HCI pipeline in order to play more meaningful roles in developing and leading this movement. In addition, such an approach will raise the level of awareness of the existing scientific knowledge in developing countries and perhaps lead to increased and more meaningful scientific collaboration.

Successful CSCL will need to draw on the best lessons being learned in computer-mediated communications (CMC) and computer-supported cooperative work (CSCW) from around the world. We must ensure that the sociotechnical issues raised in these communities are considered adequately in our work building these linkages and at building trust and common ground required for such projects [4, 33].

International Scientific Collaboration Model

Although the idea of globally distributed knowledge work is important, it must not remain an abstract concept. Rather, we must explore concrete organizational models that will both facilitate the conduct of distributed knowledge work and encourage the study of distributed knowledge work. One such mechanism is the concept of a "collaboratory," a blending of the words "collaboration" and "laboratory" [36]. In 1989, Wulf called the collaboratory "[A] center without walls, in which the nation's researchers can perform their research without regard to physical location-interacting with colleagues, accessing instrumentation, sharing data and computational resources, [and] accessing information in digital libraries."

The Computer Science and Telecommunications Board of the National Research Council (NRC) further clarified the collaboratory concept in a report titled *National Collaboratories: Applying Information Technology for Scientific Research* [27]. This report also raised awareness within the scientific community about the application and use of the collaboratory concept. However, a collaboratory is more than an elaborate collection of information and communications technologies; it is a new networked organizational form that also includes social processes; collaboration techniques; formal and informal communication; and agreement on norms, principles, values, and rules.

To date, most collaboratories have been applied largely in the sciences (such as physics, upper atmospheric research, and astronomy) with varying degrees of success and failure. Recently, collaboratory models have been applied to additional areas of scientific research such as HIV/AIDS in both national [34] and international [31] contexts. Since the emergence of these collaboratories, a substantial and growing knowledge base has emerged to help us understand their development and application in science and industry [11, 12, 27, 30].

Given that much of this work has been supported by national science bodies in the United States, the focus for providing this collaboratory infrastructure has been largely U.S. researchers and their counterparts in Europe. However, the benefits of the collaboratory approach extend far beyond U.S. and European researchers and even beyond the physical sciences.

The collaboratory model has tremendous potential for improving scientific collaboration between developed and developing countries and between developing countries themselves. Given the distributed nature of collaboratories, it is now possible to include, as active participants, scientists working in developing countries in research projects, providing mentoring and allowing them access to the people, resources, and facilities based in developed countries, and vice versa. However, in order to take full advantage of the possibilities of this model, we have to extend it beyond the domain of the physical sciences into the social and behavioral sciences, as well as into other areas of socioeconomic activity.

Extending the collaboratory concept to include both social and behavioral research as well as more scientists and practitioners from the developing world could potentially strengthen the concept. Moreover, such an approach provides us with opportunities to learn more about the social and technical factors that support distributed knowledge work between developed and developing countries and can allow greater access to and contribution from the knowledge contained within developing countries. In addition, it may contribute significantly to the socioeconomic development of these countries.

Conclusions

Distributed knowledge work is becoming increasingly important. One manifestation of this type of work, global trade in services, can contribute significantly to socioeconomic growth in developing countries around the world. However, in order for developing countries to participate as partners in globally distributed knowledge work, it is critical that we understand the social and technical factors that support such work, particularly between developed and developing countries.

This understanding may come from increased access to and dissemination of the scientific knowledge being generated in developing countries. Important research is being conducted on the application of information and communications technologies to societal goals in a number of developing countries in Africa, Latin America, and Asia. Harnessing this work and strengthening the research partnerships between developed and developing countries can make another contribution. These tasks call upon the HCI community to adopt a global perspective. We must both share HCI knowledge globally and contribute HCI expertise to the design of the information tools that will enable global integration and development.

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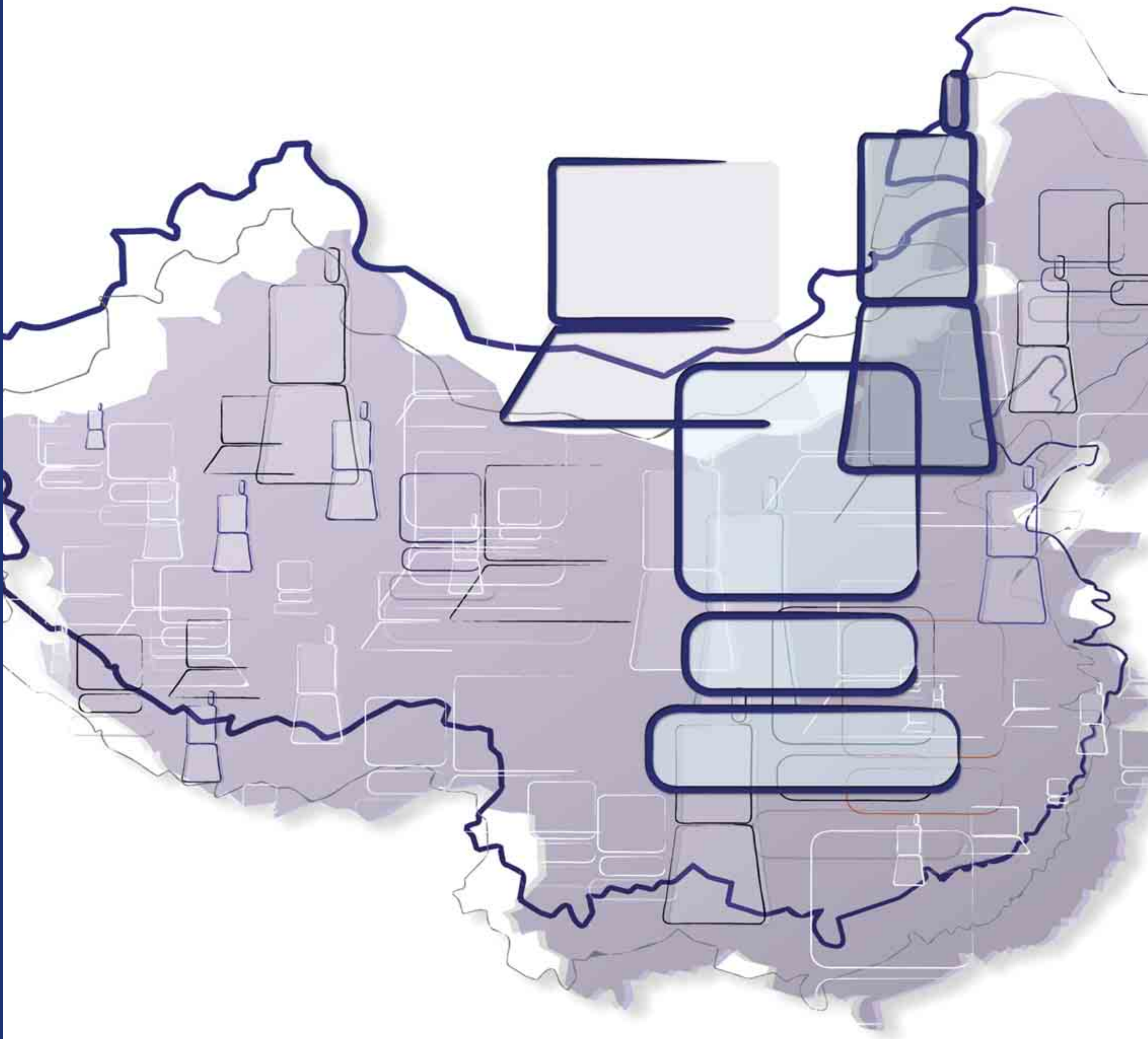

Human-Computer Interaction Research and Practice in China

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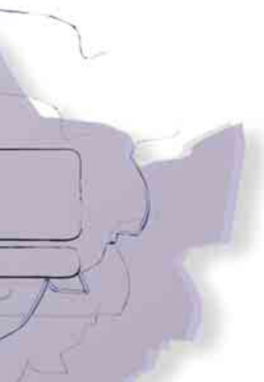
Computers and various communication devices are becoming an integral part of daily life for many Chinese. The number of PC, Internet, and mobile phone users has grown significantly in China in the past 10 years. In contrast to this explosive increase, human-computer interaction (HCI) research and practice in China, the goal of which is to bring the real power of computing devices to end users, is in the early stages of growth. This article will briefly summarize research on and practice of HCI in China in the areas of interface technology, multimodal user interface, and human performance for HCI and



usability. Future opportunities for human-computer interaction research and practice will also be discussed.

Research on and practice of human-computer interaction in China has a relatively short history, compared with its history in the United States and Europe. People in China only recently began to recognize the significant contribution of HCI research to the spectacular success of the whole PC industry and the Internet. I expect HCI to make a major contribution to the future development of next-generation information technology in China, as it has elsewhere.

China is becoming the biggest market for PCs, laptops, and mobile phones. About 10 million PCs are shipped every year. Although China is by far the largest market in Asia and already ranks number two in the world, we still can imagine the huge growth potential given the country's 1.3 billion people. Partway into 2002, the number of mobile phone users was 190 million, which is an increase of about 45 million since the previous year. It was predicted that this number would increase an additional 10 million, to a total of 200 million by the end of 2002.

The number of Chinese Internet users has also been increasing rapidly. The most recent report on the development of the Internet in China, prepared by CNNIC (China Internet Network Information Center, 2002) shows that the number of Internet users has grown to 45.8 million, up from about half a million in 1997. The number of computers having access to the Internet is about 16.1 million, and we can expect additional significant increases in the future. HCI research in China is also growing, although it has not kept pace with the tremendous increase in the use of computing devices.

HCI Research

HCI research is usually interdisciplinary and is diverse in nature. Following are four areas of HCI research in China: interface technology, multimodal user interfaces, human performance for HCI, and usability.

1. Interface Technology

In the last 10 years, Chinese handwriting and speech recognition, text-to-speech (TTS), and Chinese input methods using the QWERTY keyboard have been perceived as attractive user interface (UI) technologies. Much significant progress has been made in these areas. However, it is also evident that, although Chinese input is not an absolute obstacle to the use of personal computers, Chinese handwriting and speech recognition have not proved to be the easiest input technology for Chinese.

Handwriting and Speech Recognition

Chinese handwriting recognition is certainly a successful area in both research and applications. The Institute of Automation, part of the Chinese Academy of Science (CAS), developed the first Chinese handwriting recognition system in 1985. Through some 20 years of research and development, a current state-of-the-art system from HanWang (a company started by researchers from CAS) can recognize more than

27,000 Chinese characters with an accuracy of 99.8 percent for noncursive writing at a speed of 12 Chinese characters per second. The company also provides an embedded version for palm-size devices. It was estimated that there are more than three million users using handwriting recognition systems in China. Although impressive, this number is very small compared with the number of PCs in China.

Continuous Chinese speech recognition is another important research area in China. Microsoft Research Asia and IBM have played a critical role in this area. IBM's Via-Voice was the only voice-recognition system for PC software in China until Microsoft Research Asia developed its own system for a Chinese version of Office XP. After 15 years of research, the Institute of Automation announced its first voice-recognition system targeted mainly for voice portal, information service, and embedded systems.

Microsoft Research Asia and a lab at the University of Science and Technology of China have developed new TTS systems. One of the interesting features of these systems is mixed Chinese and English capability. The wide use of mobile computing devices in China creates a great opportunity for both telephony speech recognition systems and TTS technology for speech dialogue systems.

Chinese Input Systems

The biggest challenge when people first attempted to use computers to process Chinese more than 20 years ago was to find an optimal coding system to represent thousands of Chinese characters. Today, people use the standard QWERTY keyboard to input Chinese characters instead of having a special keyboard. Each Chinese character must be mapped to a series of English letters on a standard QWERTY keyboard. Unique combinations of letters determine each Chinese character to be input. More than a thousand variants of this basic input system were invented in the last 20 years and fewer than 10 are still used. Two fundamentally different approaches are to code Chinese characters by pronunciation or stroke structure. The pronunciation-based (PinYing) system is widely used, and the stroke-structure-based system is usually aimed at professional typists. Using these systems, a champion typist can type more than 120 Chinese characters per minute.

Because Chinese input is no longer an obstacle for Chinese information processing to the degree it used to be, people are raising their expectations about its ease of learning and use. Unfortunately, only a few usability studies on Chinese input system have been prepared on and reported for these thousands of input systems.

Chinese input systems for mobile devices are becoming another urgent research area. Unlike input systems for the PC, mainstream input methods for mobile devices were not originally developed in China. Because of the popularity of short message service (SMS)—about 30 billion short messages in the first six months of 2002—applying easy and rapid input methods using small buttons is still an interesting area for research and development.

Natural User Interface

Besides the traditional handwriting and speech recognition technology, enabling technology for next-generation natural user interfaces is also a critical part of overall interface technology research. Microsoft Research Asia has conducted broad research on pen computing and digital ink. Some of the work on digital ink by Microsoft Research Asia has already been incorporated into the Microsoft Tablet PC to support free-form note taking. Human interface-based vision technologies, such as gesture recognition, face recognition, lip reading, and sign language, are also being explored in China.

Virtual reality was considered one of the new HCI paradigms for the next-generation user interface. Research in this area has focused on 3-D interaction in a virtual environment, information visualization, and system tools to build distributed virtual environments. Research on wearable computers, ubiquitous computing, and computer-supported cooperative work (CSCW) are also active research areas in China.

2. Multimodal User Interfaces

Developing multimodal user interfaces attracts many researchers in China. Research in this area has tried to integrate various interface technologies to define a new paradigm of user interface for different applications. UI design tools and formal descriptions for multimodal user interfaces are also being developed and explored.

"Multimodal User Interface and Its Application" was a key project on HCI funded by the National Science Foundation of China (NSFC) in 1995. It was the first and, at the time, the biggest HCI project in China. This interdisciplinary project involved both computer scientists and psychologists and had the goal of understanding the paradigm, interaction design, implementation, evaluation, and applications of multimodal user interfaces. One indirect but critical impact of this project was that the importance of HCI was well recognized and the value of including both technological and cognitive scientists was understood. As recognition of the importance of HCI has grown, additional HCI research projects have been funded. In 1996, the first International Conference on

The wide use of **mobile computing devices** in China creates a great **opportunity** for both telephony **speech recognition** systems and **TTS** technology for **speech dialogue** systems.

Multimodal Interfaces was held in Beijing and became a regular conference until it merged with the Perceptual User Interface Conference in 2002.

3. Human Performance for HCI

Ergonomics and human factors research has a long tradition of studying human performance in human-machine systems. Human factors research in China can be traced back more than 40 years. It was, therefore, quite natural to investigate human performance in human-computer systems when HCI was first discussed in China more than 15 years ago. This research attempted to understand the effects of computer hardware and software design on human performance, such as design of the visual display terminal, menu interface design, Web navigation, and effective browsing. Subjective evaluation, task completion time, physiological measurement, eye movement patterns and other measurements were used in these studies. Some experiments were also performed to understand the underlying processing of Chinese typing.

4. Usability

Unlike previous areas we discussed, very little serious work has been carried out about usability because of the low awareness of usability in China. When I first helped to do usability tests for Motorola and Symantec about five years ago, most companies in China did not recognize usability as a valuable aspect of products. Implementing functionality was the only focus of the product development at that time.

The importance of usability is now being recognized in China.

The importance of usability is being recognized today. Microsoft Research Asia (MSR) established its first usability lab in China more than two years ago. At about the same time, Siemens also opened its first user study lab in China. Whereas the usability lab at MSR is mainly for research purposes, the lab at Siemens provides usability services for the products of both Siemens and other companies. More usability labs in both local industry labs and universities have been established since then.

HCI Practice and Funding

To better understand the state of HCI research, it is necessary to understand the research infrastructure for HCI in China, which is different from that in the United States and much of Europe. One key difference is that HCI research in China is largely done in universities and by the Chinese Academy of Science, not in local corporate labs. This has been changing recently as foreign corporations like Microsoft, Intel, and IBM have opened research labs in China.

The National Laboratory of Human Factors at Hangzhou University (now Zhejiang University) started interdisciplinary HCI research on human performance, user interface design guidelines, and multimodal user interfaces as early as in 1992. This research finally evolved into a joint project with Beijing University and the Institute of Software of the CAS, funded by the NSFC. The lab is currently the only HCI lab hosted by a psychology department in China.

The Human-Computer Interaction and Intelligence Engineering Laboratory at the CAS Institute of Software developed from a software engineering background. Founded in 1999, it focuses on multimodal integration, cognitive models and distributed cognition, context-aware interface, pen interface, and sketch understanding. The Advanced Human-Computer Communication Technology Laboratory is another research institute at CAS that conducts research on multimedia and intelligent human-computer interaction technology, including biometrics, face detection, and gesture recognition.

The Institute of Human-Computer Interaction and Media Integration at Tsinghua University focuses on distributed multimedia and communications, human-computer speech interaction, and human-face recognition and synthesis. Gavriel Salvendy, who currently chairs the Industrial Engineering Department at Tsinghua, has been building up a human factors program there since October 2001. Usability and HCI are two major research interests for the new program. The department is also launching a new cooperative plan with the recently created usability center of Legend Research Institute, Legend Group Limited. Legend is the largest PC manufacturer in China.

Long-term research on human-computer interaction has been listed as an objective for various national research projects. Funding for human-computer interaction is provided mainly by the National Science Foundation of China, National 863 high-tech project, and National 973 fundamental research project. The National Science Foundation of China has wider coverage of the research areas in human-computer interaction.

As mentioned in the previous section, China recently attracted many foreign companies to open research and development centers because of its huge talent pool and market potential. Research is now being conducted in China by Microsoft, IBM, Motorola, Intel, Siemens, and Nokia. Following is a brief overview of some work going on at these organizations.

• *Microsoft Research Asia's* research on next-generation user interfaces is one of the four main research directions at Microsoft Research Asia, which was established in Beijing in 1999. Its research covers natural user interfaces for pen computing, digital ink, human-computer interaction models, usability, speech recognition and interface, TTS, and natural-language processing.

• *IBM China Research Center* focuses on research in alternative Chinese input methods for mobile phone or other small devices and Chinese handwriting recognition for both PCs and embedded systems.

• *Motorola China Research Center* (MCRC), established in Shanghai in 2000, conducts human-interface research to support Motorola's mainstream products in the future China market. Its research topics cover human-machine interface technologies, such as embedded Chinese speech recognition, speech generation, Chinese natural-language processing, and Chinese character recognition and multimodal communication over China's third-generation (3G) wireless systems.

• *Intel* opened the Intel China Research Center as an information technology research and development center in Beijing in 1998. The center focuses on applied research in Internet, speech, and intelligent human-computer interaction, including speech signal processing and recognition, speech synthesis, handwriting and natural-language processing.

• *Siemens* and *Nokia* also have labs to focus on usability test for their products in China marketplace. These foreign corporate research and development labs have been influencing HCI research and practice in China.

Besides research at universities and industry labs, HCI-related standardization is another driving force for funding HCI practice in China. The China National Institute of Standardization is a government organization responsible for establishing a standards system similar to that of the International Standards Organization (ISO) that includes the standards for human-computer interaction. As part of its recent work, the institute is working on a national standard on human-centered design processes for interactive systems, which is the equivalent of ISO 13407. We anticipate that additional similar standards will be adopted in the future.

Challenges and Opportunities

Rapid growth in the application of computers and use of mobile devices provides more space for HCI research and practice in China. The HCI community in China is facing both challenges and opportunities in the future.

HCI Professional Community

The research community of HCI professionals is still very small in China. There is, as yet, no national HCI professional organization to organize professional activities and no annual conference to exchange research findings and share the vision. As the importance of HCI is becoming more widely recognized, we anticipate having a large and strong HCI professional community in China. We hope that ACM SIGCHI can help with the development of this community.

Impact on Product Development

User interface design is still not an integral part of software development in China. Research at universities has no direct impact on software and product development yet. The UIs of all major office productivity software packages developed in China are still quite similar to those of Microsoft Office. The publisher of a leading local office suite touted, as one of its key features, that UI for the suite is 100 percent identical to that of Microsoft Office. With more research advances in HCI, it is inevitable that state-of-the-art research results will be incorporated into new products.

Education and Training Program

University education is essential for capitalizing on the enormous potential of HCI in the future. Currently almost no interdisciplinary education programs for HCI exist in China and no HCI textbook is available for university students. HCI is still not a required course in most top computer science departments in China. Beijing University has been the first top computer science department to teach a human-computer interaction course for undergraduate students. Most of the top 10 universities do at least offer an HCI course for their graduate program. Further development of advanced training programs for HCI practitioners is also very necessary.

Job Opportunities for Usability Engineers

Today, almost no job positions for usability engineers in the software industry exist in China, except in some foreign companies. Unlike many American and European companies, leading software companies in China usually do not have a professional usability test group. Providing more job opportunities for usability engineers will not only help improve the quality of software and products, but will also facilitate the growth of HCI in general in China.

Short- and Long-Term HCI Research

Although applied HCI research in China is increasing, much less fundamental or basic research is being conducted in China than in United States and Europe. Applied empirical studies on existing HCI systems do not help to solve the HCI problems specific to China. A balanced vision of both short- and long-term HCI research is critical in order for us to advance in solving known problems and identify promising research areas.

People are becoming increasingly **interested** in not only the “computer” side of HCI but also in the **“human”** side of HCI, including **usability**.

Conclusions

China is becoming the largest marketplace for mobile communication and computing devices. This is taking HCI research to a new level and pushing HCI beyond the desktop and into our pockets, couches, and streets. People are becoming increasingly interested in not only the “computer” side of HCI but also in the “human” side of HCI, including usability. Given the number of users, China must do more state-of-the-art research, in order to significantly affect future products and begin to play a leading role in some areas of HCI.

I am highly optimistic about the future of HCI in China. In the last three months of 2002, I had the opportunity to participate personally in a number of events that seem to support this optimism:

1. The APCHI 2002 conference was held in Beijing for the first time. It was a very successful conference, at which I was honored to deliver the keynote speech.

2. I reviewed a national standard for Human-Centered Design Process for Interactive Systems. Additional standards relevant to HCI are being drafted.

3. A special session on HCI research in China at HCI International 2003 is being organized, at which I have been invited to give a presentation.

4. The writing of this article for *interactions* about HCI research in China.

I believe these are not isolated events. I feel that great opportunities for HCI research and practice are coming, and I am excited about the opportunity to personally play a role in this bright future.

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