Research Report

Overcoming Blind Spots in Interaction Design: A Case Study in Designing for African AIDS Orphan Care Communities

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Abstract

*The process of designing technological systems for the developing world is a challenging task. In a project that we undertook in the summer of 2007 using an iterative design process, we attempted to develop delay-tolerant networking technology on mobile phones to support workers at AIDS orphanages in Zambia and South Africa. Despite extensive preparations and research, we found that conditions on the ground were radically different from what we had anticipated, and we had to quickly re-group and redefine our strategic goals. This experience made us realize that, for this type of design, resiliency and contingency planning were the most valuable tools in our interaction design toolbox. In response to changing conditions, we rapidly prototyped a different mobile telephony application called Nomatic*AID that provides a feedback loop among donors, non-governmental organizations (NGOs), and field workers. In this paper, we reflect on the redirection of our work once we reached our field site and our resulting acceptance of design blind spots. We present lessons we learned to help practitioners meet their goals in the presence of considerable and obvious design distance.*

Introduction*

When creating interactive technology for underserved populations in the developing world, it is not unusual for interaction designers to be far from the people whom they are trying to serve. This distance can be geographic, but it can also include social and cultural distances. While this is true whenever a designer is making any tool for others, the distances are more readily acknowledged, seen, and felt in Human-Computer Interaction Design for the Developing World (HCI4D). Despite designers' best intentions, they lack the firsthand knowledge that comes from constant, intimate contact with the people and situations for which they are designing. Conversely, local experts have rich, situated knowledge, but they frequently lack enough understanding of technology to provide designers with the details required to produce effective information technology interventions. The solution offered by current design methodologies is to bring both sides together in the locale where the technology is to be used, where they can then participate in iterative, rapid prototyping. In

**The authors wish to thank the following individuals and organizations for their assistance in providing us information, access, and funding to better understand the people and places we have reported on: The Agathos Foundation, Newport Mesa Church (California), Harvest City Church (Zambia), Neal Lesh, Al Morell, George Palo, UC Council on Research, Computing and Library Resources, Theo Patterson, and an anonymous foundation.*

the context of the developing world, however, there are real, practical obstacles to doing this. Transportation can be expensive or not available at all. Logistical issues can be complex. There may even be safety and security concerns. In this paper, we reflect on how we dealt with these practical problems while designing pervasive computing applications for non-governmental organizations (NGOs) in southern Africa.

When we began our design process, our goal was to design a mobile telephony application to support the care of AIDS orphans in Zambia and South Africa. To the degree that our original application was useless in the field, we clearly failed to establish the right means of reaching our goal while working from afar. Despite extensive conversations with stakeholders and experienced field workers, as well as reviews of relevant literature, we prototyped the wrong system and took it across the globe, from Los Angeles to Africa. While our initial attempt was unsuccessful, we count it as a success that we ultimately were able to identify four mobile phone applications that, with further refinement, may hold promise for successfully helping the people whom we met. We discuss one of those applications in this article: a tool that creates a feedback loop between private financial donors in the developed world and NGO field workers on the ground.

Not only did we reassess our knowledge upon arrival, but we also began a longer-term reflection on our approach to distill why, despite following well-known design best-practices, we had initially failed. The result of this reflection is the realization that, as a result of our fundamental inability to know the scope of the social and physical infrastructure from a distance, it may have simply been impossible to achieve success in the way we initially envisioned. We realized that knowledge of design processes is as important as an explicit acknowledgment of one's shortcomings—to the degree that preparing for them becomes part of the design process.

We hypothesize that our inability to understand our interaction setting is amplified not only by distance, but also by the nature of pervasive computing itself, which has been theorized as being especially influenced by the embodiment of such technology (Dourish, 2001). *Embodiment,* in the sense used by Dourish, draws our attention to the ways in which interactions with devices and people "are embedded in the world, and [to] the ways in which their reality depends on being embedded" (p. 18). This concept is important for pervasive applications, such as those deployed on mobile platforms, because the interaction with the technology occurs while the user is especially engaged with the physical and social world. In addition to being good software artifacts, these applications need to easily adapt to their embedding; in fact, they cannot be good software artifacts without attending to the setting in which they are used. This adaptation can take many forms, from fully automatic intelligent systems to well-designed user interfaces, either of which may leverage sensors and user input to subtly align the application's behavior with the user's.

The remainder of this paper is organized as follows: In the next section, we discuss a case study in designing a pervasive application for a mobile phone in Africa. Then, we discuss how we were able to successfully adjust to changing conditions on the ground and how interaction designers for the developing world are likely to find that they are separated from the objects of their designs.

Case Study

Many researchers, like ourselves, have experienced pervasive computing's recent jump across many cultural and socioeconomic boundaries (Bell, 2006; Burrell & Anderson, 2008; Medhi, Sagar, & Toyama, 2007). Recognizing the growing dispersion of information technology globally, and the advances made by interdisciplinary teams of technology researchers, we developed an interest in testing the boundaries of "ubiquitous" computing, while simultaneously seeking to meet the needs of an underserved population. Available opportunities and personal interest led us to pursue work in the domain of AIDS orphan care in sub-Saharan Africa. Using a user-centered iterative design process, we began to gather requirements for a mobile phone application that would assist in the administration of community care centers for AIDS orphans. In this section, we describe our process as a case study in iterative application design.

AIDS Background

Our first goal was to understand the scope of the problem of AIDS in southern Africa. AIDS is a disease that does not affect the world equally. It is the leading cause of death in sub-Saharan Africa

(UNICEF, 1999). As of 1999, 11 million of the 14 million people who have died of AIDS have been African. From 1999–2003, an additional 10 million Africans died of the disease (UNAIDS, 2003). Of those deaths, approximately 25% have been children (Mukwaya, 1999). Approximately 20% of sub-Saharan Africans have AIDS, and as an example of the impact of that statistic, the average Zambian man dies at age 39 (WHO, 2007). As a result, approximately 20% of Zambian children are orphaned, a figure that has been increasing by 2% every five years (UNICEF, 2004). While the impact of AIDS varies dramatically among the heterogeneous African countries, it is clearly such a crisis in Zambia and South Africa (UNAIDS, 2006) that it is worthy of attempts at intervention.

Preparation in the United States

As researchers working Southern California, Zambia and South Africa were far from us in many ways. We knew little of the conditions on the ground, and we were certain that what we did know was inaccurate in important ways. We recognized that these shortcomings could be remedied by traveling to an AIDS orphanage in Africa, but such a trip would be costly, and to make the most of such a journey, we would need to lay the groundwork for our interaction design efforts before we left. We knew we were going to need to iterate many times on this design, but we hoped to do as much as possible before incurring the travel costs.

The first stage in our process was to interview as many people as possible from our remote location who could provide insight into the care of orphans in Africa. We formed a partnership with the Agathos Foundation, an NGO that works in the area of AIDS orphan care. This partnership granted us access to knowledgeable individuals whom we interviewed and used to further extend our contacts. From this cohort of interviewees, we learned a great deal about what it looks like to care for orphans in Southern Africa. We also heard a lot about the impact of international political processes on the people in Africa. We spoke with short-term volunteers from orphanages in South Africa who were spending a period of their life serving, but did not envision an entire career spent in the field.

From there, we interviewed representatives of a mobile health care application company operating in Rwanda and Kenya. This company maintains applications for PDAs used to monitor medication compliance in AIDS and tuberculosis patients. These interviews gave us insight into health care research in Africa.

We then interviewed full-time volunteers from an orphanage in Sierra Leone who had returned home on furlough. Although these children were orphaned by a civil war, we learned a lot about the security concerns of field workers and the basic infrastructure needs of care communities.

We spoke with HCI (human-computer interaction) researchers who had experience designing applications in developing nations. From these researchers, we learned a lot about the difficulties associated with language literacy, language barriers, and basic computer fluency among the people who used the technologies.

To supplement our interviews, we reviewed research literature on prototyping efforts in the developing world. For example, we looked at methodological and design concerns (Tongia & Subrahmanian, 2006; Koch & Caradonna, 2006; Williams, Anderson, & Dourish, 2008), as well as system design work, such as research projects that provide connectivity for nomadic communities (Doria, Udn, & Pandey, 2002), applications for the semi-literate in remote regions (Ghosh, Parikh, & Chavan, 2003), and systems for monitoring wildlife in Africa (Juang et al., 2002; Liu, 2004).

One of the primary points we were informed of was the importance of creating "sustainable" interventions. In this case, the term was not related to ecological concerns, but rather to the economic and social viability of an intervention's survival after the research prototyping is done. We learned that it is important to consider training and to include locals in the process of developing and prototyping a technology (something we knew from participatory design theory), but that there is also frequently an economy of locals whose income is obtained throughout employment with successive research endeavors that came into town. We heard about the uncomfortable tension between researchers wanting to see local people who are self-sustained and the stream of research projects that are also inhibiting that very goal.

We also discovered that, because of the nature of HIV transmission, most orphans in our contact's care facilities do not actually have HIV. They are "AIDS orphans" because their *parents* died of the disease. This holds true until they reach sexual maturity, at which point they face the same sobering statistics that their parents faced. We also discovered that the UN definition of "orphan" includes "single" orphans and "double" orphans, depending on whether one or both parents have died.

All of this background research suggested that a fruitful user population would be NGO field workers. Often, field workers come from developed countries to work for stints of several months to years in a developing area. They will typically work on a particular relief project or with a particular NGO during that time. The advantage of working with this population was familiarity with and access to the technological infrastructure that we expected to use. Our research revealed a host of concerns for NGO field workers, including issues of personal security, negotiating differences in a variety of infrastructures such as power, water, and health care, and communicating with professional and personal contacts who were not in the field.

This also led us to identify the technical problem of a need for a better information flow from NGO field sites back to their headquarters. Field sites often have knowledge of the location of vaccines, children in crisis, and refugees that logistical managers can neither account nor plan for. Previous researchers had found that disconnected electronic communication could be supported through the physical transfer of digital data. This style of networking is often called "sneaker-net." Although the scale is different, a similar situation occurs in modern biology labs that ship hard drives full of data overnight to colleagues that would otherwise take days to transfer over a network connection. This is also a service that many cloud data-storage providers offer. We began prototyping such a communication system for field workers based on delay-tolerant networking technology (Burleigh et al., 2003). In this paradigm, participants physically cooperate to shuttle data back and forth to the Internet transparently. For example, an individual can send an e-mail using a normal e-mail client. The computer hides the details of the delay-tolerant network from the user and provides feedback that the e-mail has been sent. In fact, the data are transferred by Bluetooth to a PDA which a human courier walks into town—hence, "sneaker-net." Once the data are near an Internet access point, it is wirelessly sent on its way. As a computer science abstraction, it can be thought of as a highly unstable network topology, one characterized by frequent long disconnections between nodes. The potential for automatically learning the roles of users in the system and optimizing delivery routes without user intervention was alluring.

Reality on the Ground

Armed with this knowledge and a prototype, in the summer of 2007, we took a team of four people to Ndola, Zambia, and then to a rural town in South Africa, to undertake the next step in our iterative design process of deploying and conducting user studies. It took a year of grant-writing and several months of work with our IRB (ethics review board) to get the money and permissions that we needed to support this relatively simple trip. Our first week took place in Zambia, where we planned a large number of visits to a variety of sites. Our second week took place in South Africa, and it was intentionally "deep," as we remained in one community care village for AIDS orphans.

As soon as we arrived in Zambia, however, we realized that something had gone very wrong with our preparations. Despite research that indicated that cell phone penetration was only 18% in Zambia (ITU Telecom Africa, 2008), we were amazed to find that we had access to cell phone network coverage everywhere we went, including some remote villages. Far off the tourist track, in the industrial mining city of Ndola, we found that cell phones were pervasive. Remarkably modern models from all of the major phone manufacturers were being sold by and to locals, on sheets laid out on sidewalks. The phones represented a complicated mix of region-locked, refurbished, and new phones. One of our Zambian hosts even referred to a class of cell phones as "disposable"; he would buy one of these when traveling to a different region, to maximize connectivity and minimize cost, and then discard the phone upon return.

There was an economic ecosystem that would take such discarded phones and recycle them back into the market. Figure 1 shows a sign from a local phone dealer in Ndola offering to "repair" cell phones, a service that is nearly unheard of in the developed world. Cell phone infrastructure was visible even in places where motor vehicles were rare.

Despite following our established design methodologies, we found that our primary technological

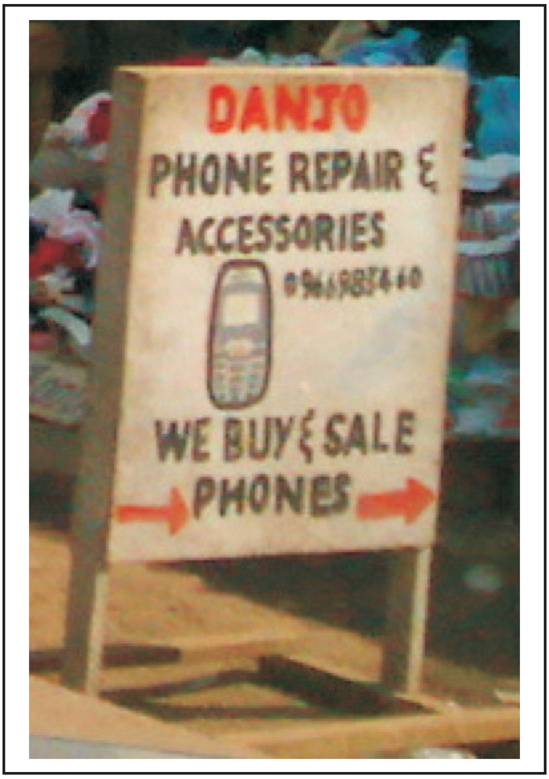

Figure 1. Cell Phone Repair in Zambia.

prototype was not nearly as useful as we had expected. Where there is cell phone connectivity, there is also network connectivity. The quality of the data transfer through these networks and through the many urban Internet cafés was poor, but it was there.

If that was the *technical* reality on the ground, the complexity of the AIDS orphan story was an unexpected social reality. It was impossible to separate the "AIDS crisis" from the "orphan crisis," the "malnutrition crisis," or the "economic crisis." The Zambian orphans were half the height of U.S. children due to malnutrition, the urban teens were addicted to sniffing glue, and they all faced serious educational challenges. There was limited health care, detritus from development projects whose funding had clearly dried up and moved on to something (apparently) more pressing, and persistent pollution from grass fires. But the Zambian people were largely friendly, happy, and willing to share their stories and resources with us.

Shocked by the discrepancy between our expectations and what we found, we began to reassess our preparation. We had a breadth of experience on our team. One of our team members was a native African, we were hosted by an NGO worker who travels to southern Africa several times a year, one of our team members had lived in a different place around the world on average every 1.5 years, and another was an international businessman. We were intimately familiar with UN reports on AIDS in Africa, and we were experienced interaction designers. But this background, in addition to our research and interviews, had not been sufficient preparation for us to hit the ground running. Reflecting on the preparation for our arrival in Zambia, it became apparent that we did not have a sufficiently detailed picture of the infrastructure surrounding the problem of interest to us. We did not ask the right questions before we left to ensure that we had an adequate knowledge of the users, the sites, the artifacts, and their interactions. We had little way of knowing that we were missing important information about the environment, and we did not explicitly recognize how these blind spots were inevitable. Although we prepared by prototyping a solution, it turned out to be premature, and while our understanding of the design process helped, we had started designing before we had key pieces of information that would identify the interactions around which we could propose an intervention.

Faced with reality on the ground in Zambia, we quickly reformulated our strategy. First, we threw out our prototype, rapidly reassessed our knowledge, and determined what we had access to. We grudgingly stopped thinking of our trip as a "deployment," and we began to re-frame our time as another iteration of discovery, to see where we had blind spots in our understanding of the infrastructure, broadly construed (Mainwaring, Chang, & Anderson, 2004). We began an intensive and rapid interrogation of the setting by observing and participating in as many different combinations of *users, sites,* and *artifacts* as possible. We identified potential local users and stakeholders whom we wanted to contact. From this list, we were able to get direct interviews with a wide range of relevant individuals, including five NGO volunteers (e.g., Peace Corps), two orphanage founders, four community leaders involved in orphan care, a government social service worker, urban and rural orphans both in and out of care networks, a telecommunications services provider, several elementary school teachers, and spiritual community leaders.

Discussions with some of these individuals led us to investigate a number of unplanned sites of interest. We visited four types of community schools in Zambia and South Africa: a rural community school, a school in a "suburban" slum, a state-run elementary school, and a state-run high school. We attended several church services, and we visited a Zambian AIDS hospice, a cemetery, economic cooperatives, and mining operations. We visited a state-run telecommunications facility, Internet cafés, and cell phone stores. While artifacts can be broadly considered, we focused on technological artifacts and obtained local cell phone cards and surveyed existing phone models. We investigated the technology available in the Internet cafés.

We also began to consider some of the interactions that were occurring between these elements and looked more closely at those places. Observing users and sites together, we saw people going to funerals for victims of various diseases, we walked with orphans as they went to and from school, we attended spiritual ceremonies, and we watched how care was delivered to several people. Generally speaking, we found that the best infrastructure in Zambia was comparable to the worst areas in South Africa, such as the care village where we stayed.

In the following sections, we describe in detail some of the things that we wish we had discovered prior to our trip.

Socio-Technical Infrastructure

The State of Orphan Care

The conditions for orphan care in Zambia and South Africa were very different. South Africa has a formal process for the management of orphans that includes social service work, a strategy for community care (as opposed to the generally disparaged orphanage model), registration, and schooling. The largest problems that we saw in South Africa were related to a lack of both personnel and resources to implement the strategies that were in place.

Additionally, in rural communities, there was a problem related to identity management. Most of the processes put in place by the South African government required documentation in the form of birth certificates for children and death certificates for parents to facilitate transfer of guardianship. In rural communities, like the one we visited, people might live their whole lives without interacting with government institutions. When a child in crisis required intervention by local care-givers, there was often no such documentation. This resulted in a great deal of frustration when state social workers would demand proof of guardianship from care facilities while reviewing administrative records. The care facilities were often embedded in the community and were interested in helping children in crisis. For them, documentation was a secondary consideration to starvation and exploitation of the children. In the absence of documentation, social workers were at a loss for how to assemble resources for the children ostensibly under their purview.

This lack of identity credentials has implications for all manner of information systems design, particularly for those who attempt to keep track of individuals at any level. Identity is central to industrialized banking and credit. It is assumed for travel. It is required for computer security and even implied in e-mail design.

In Zambia, the situation was very different. The evidence of a national infrastructure for caring for orphaned children was orders of magnitude smaller. Any semblance of organized supervision of children was coordinated by grassroots networks within the community itself. Communities of orphans often banded together to form something between a family and a gang. Although there was substance abuse among the urban children, violence was rare. We did not have insight into other forms of abuse that may or may not be occurring. In the more suburban and rural areas of Ndola, multi-room shelters served as a meeting place for orphans and non-orphaned children during the day. There was often an adult teacher whose presence contextualized these locations as schools, but the resources for teaching were nonexistent. There were no supplies apart from benches in these rooms, and the two books that we saw were a Christian Bible and a UN directory of services.

The Needs of Orphans

As we tried to identify what the needs of the orphans were and how technology might assist them, we were aware that the primary needs of the orphans in Zambia were basic. Food, medicine, clothing, and clean water were all noticeable concerns. Beyond those needs, other services, from support for education, more substantial shelter, and mosquito netting, all the way up to and including economic opportunities, were all lacking. Most of the orphans were surviving from day to day, but their futures obviously contained significant challenges.

The Skills of Users

In both Zambia and South Africa, we found there was a population of people who could and were using desktop computers, as well as a much larger population of people who were successfully using text messaging on cell phones. In fact, largely because of cost, text messaging and flashing (mobile calls that are intended to be missed) were the preferred method of computer-mediated communication (Donner, 2007). We learned through interviews that, despite a high rate of illiteracy, the Zambian people were still making use of text-messaging. Time prevented us from understanding what conventions were used to manage this contradiction. In South Africa, it was not unusual for the older orphans who were in care networks to have access to cell phones and to use text-messaging with each other, as well as with former volunteers from the United States. This was true despite their often never having left the town they lived in. In a similar pattern as in the United States, there were informal networks of computer experts and cell phone-savvy friends that people used when they had a problem with their computing devices, but had inadequate knowledge of how to fix the devices themselves.

The State of Networking Technology

Our subsequent investigation of the networking capacity in the two areas revolved around three types of access: wired access, Wi-Fi access, and cell phone data access. Internet cafés were common in downtown Ndola. They were being used for a wide range of activities, including many individuals playing browser-based games and people stopping by to check e-mail. The cafés appeared to be operating five to 10 computers behind a single DSL line. We investigated the network quality and found that approximately 70% of the data packets between Zambia and Los Angeles were dropped, making any substantial e-mail communication impossible. It also suggested that the DSL line may have been shared upstream of the Internet café, as well.

From our interviews with Zambian telecom businessmen, it was reported that the primary reason for the network congestion is that there is only one data route out of Zambia on state-run networks, and private companies are heavily restricted from offering competing service. A major concern of the state-run company, Zamtel, was that private companies, although legally restricted from offering voice services directly, would begin to offer VoIP over their data channels.

In rural South Africa, wired network connectivity was on par with dial-up connections in the United States, except that connections rates were charged on a per-minute basis with discounted nighttime rates. This resulted in field workers often queuing up all their e-mail during the day for transmission at night.

Usage in cafés was also charged by the minute. The cost of having a private DSL line wired to a residence was reported by telecom officials as US$3,000 per month and was only undertaken to wire the homes of executives associated with mining in Ndola.

We conducted a war-drive of urban and rural Ndola (Zambia) and Loskop (South Africa). *War-driving* is the process of driving with a Wi-Fi antenna set to "listening mode," along with a GPS device recording position. This combination allows a researcher to draw a map of Wi-Fi access point positions without needing to actually connect to the network. From this survey, we found only a handful of Wi-Fi access points in approximately 50 km of driving in and around Ndola, and none in our location in South Africa. The access points in Ndola were not password protected, and they were exclusively located on the work sites of large mining operations.

As mentioned previously, cell phone access was pervasive and relatively inexpensive. In Zambia, sending a medium-quality photo and text message by cell phone cost US$0.30, as well as requiring approximately 11 minutes and 10% of the battery charge of a Nokia 6600 phone. This was likely due to the need for the phone to repeatedly transmit packets to account for the network congestion. In contrast, the cost in South Africa was US$0.17, and the process took 2.5 minutes.

From these observations, we concluded that, while the Internet was widely available at our sites, it was sufficient only for communications on the order of single photos being transferred. Streaming video, large-document transfer, or other high-bandwidth, persistent-connection communications were extremely inefficient, and in some cases, impossible.

*Nomatic*AID: The Revised Mobile Application.*

Once we had the opportunity to assess our data from the first week in Zambia and the first several days in South Africa, we identified a potential setting for a technological intervention. We observed that there were a large number of basic needs in Zambia, broadly, and among the orphans in South Africa, specifically. There were a number of NGOs of various types and foci located in both locations. There was an adequate digital network infrastructure, and distribution of cell phones in both places. There were even a number of people from developed countries who came through both of these locations and expressed a desire and interest in assisting with development projects.

However, we found that people from developed nations were somewhat skeptical about investing in development projects in the areas that we visited, because of a belief that the money would be squandered or used in a way that looked like an unsustainable approach rather than a substantive investment to improve permanent infrastructure. Both were valid concerns.

This interaction between potential donors and the field sites became the new interaction that we decided to understand. With the help of local workers, we conceptualized an online catalog in which financial donors could donate money for items that an NGO indicated were needed for an AIDS orphan care site (e.g., a book, blankets, a car). After being notified of the donation, an NGO field worker would obtain and deliver the item, then photograph the item, and upload the image back to the catalog Web site. The donor would be e-mailed a link to the URL containing the image of the purchased donation, along with any meta-data available when the photo was taken (e.g., the location of the photo). The goal of this Web site would be to create more trust in the entire donation chain, from the donor, through the NGO, to the orphan, and back again, thereby facilitating larger development projects in the future. We rapidly prototyped this system on a Nokia N80 cell phone with a Bluetooth GPS unit and connected it to a server-based Web site using a GPRS cell phone data network.

There are many caveats that would apply to such a system: It only works for physical purchases, a technical adversary could defeat the security model, a social adversary could corrupt the social trust built into the system, field workers would need training, and so on. Nonetheless, the idea resonated with many of the long-term volunteers on-site in South Africa. In a user test of our rapid prototype with two American volunteers in South Africa, they both expressed confidence in the concept of the system, despite noting that each individual transaction needed to be faster and the system needed to be more robust. They mentioned that current practices of accountability were largely associated with prospective budgeting and allocation, instead of an evaluation of purchases after the fact. They felt that a promising benefit was that such a system would enable them to keep in better communication with their financial supporters in the United States. Both of the users we were designing with wanted to meet this responsibility more effectively, but they acknowledged that it was an ongoing struggle to do so.

Design Lessons

We learned a number of valuable lessons from our initial fieldwork for this project. We believe that these lessons are particularly applicable to work in the developing world, although clearly they can be applied in other research areas, as well. Although we originally thought of our trip as a technology deployment, we had to quickly adjust to make our short visit valuable when we learned that the assumptions we had made were wrong. Fortunately, we had come prepared to *understand the infrastructure,* were ready *to change directions,* and were willing to acknowledge our design *blind spots.*

Prepare to Understand the Infrastructure

Early in our planning for our work in Africa, we had approached this trip as not only an opportunity to help, but also as an opportunity to learn. Knowing that there was a growing global use of mobile phones, we hypothesized that there may be some ways in which technology was being used in the developing world that could inform and benefit our technology use, as well. Ultimately, we did not have time to uncover such uses, but in preparing to look for them, we were also preparing to extensively probe the socio-technical infrastructure. This preparation was invaluable in our response to the unexpected conditions on the ground, and it was crucial to the design of Nomatic*AID.

Understanding the infrastructure required us to conduct an inventory of the *setting* in which our interactive technology was going to be used. Our approach was guided by previous work on embodied interaction (Dourish, 2001) and on software requirement gathering methods (Lethbridge, Sim, & Singer, 2005). Although these sources come from two fields (interaction design theory and software engineering), they converge on a view of interaction as being simultaneously situated in a social and a physical space, agreeing as well that information from users, sites, and artifacts are necessary to fully characterize the setting of an interaction.

The techniques that we used to collect data on the user's social infrastructure were provided by Lethbridge et al., (2005) and they included shadowing, participant observation, and field interviews. We evaluated a variety of sites by doing price comparisons in marketplaces, conducting Wi-Fi coverage mapping by war-driving, and mapping cell phone coverage. We evaluated artifacts by purchasing phone cards from a variety of carriers and by working with users to see the kinds of information management tools that they were already utilizing. Practically speaking, this meant having tools such as Wi-Fi antennas on hand, prepping software for probing network transmission speeds, and having a wide variety of network and electrical adaptors and alternatives immediately on hand.

It was nearly impossible to understand the technology infrastructure from a distance. Although we interviewed aid workers with field experience, they lacked the technological know-how to answer questions or offer information in a way that was relevant. Even if we had known to ask the right questions, it is unlikely that even a technologically sophisticated informant would have been able to tell us about network transmission speeds or to provide a good understanding of network coverage. This is simply not the kind of knowledge that one acquires in day-to-day life. Of course, we also read a number of academic articles and reports from NGOs. While these sources were useful in some respects, they were too dated. We were particularly caught off-guard by the level of cell coverage that had changed so dramatically over the two years that we were preparing for our trip to Zambia and South Africa.

However, our interviews and background research before leaving for Africa still had significant merit. The lack of technical information was an important reason why our initial software application was not useful, but the identification of NGO field workers as a user group remained valuable. Once we had discovered more details about the infrastructure, we were able to create a useful Nomatic*AID prototype. Had we not been ready with tools to probe and understand the technical infrastructure, however, the trip would have been wasted.

Prepare to Change Directions

Planning for things to be different turned out to be an important preparation. We were ultimately successful with the second software application because we reacted quickly once we were on the ground. Anyone who has tried to make plans in a developing region knows that schedules change without notice. We had made a handful of contingency plans, and we were mentally prepared to be flexible. Although we did not anticipate that most of the flexibility was going to be needed as a result of a mistake on our part, we were already prepared to both take advantage of unexpected opportunities and to roll with the challenges.

It was also important to know what alternatives were available. For example, when planning to visit an organization, such as a school, it helped us to identify similar organizations in the area, so that they could be visited if the original destination was closed, had moved, or could not be reached. When we realized that we were no longer deploying a technology, we alternatively attempted to embed ourselves in as many relevant routine activities as possible. Fortunately, we had brought extra equipment with us, including video cameras, digital cameras, and audio recorders, so we could collect field data whenever we needed to. We asked to use, inspect, observe, and examine the actual objects that users interacted with, even when they were apparently mundane. We documented people working with artifacts, such as supplies for orphanages, and using technology, such as cell phones.

We saw how artifacts and technology related to their environment, as well as how this relationship changed in different locales. We walked with students to their schools, slept in orphanages, attended worship services, helped at a hospice, visited a copper mine, mapped the boundaries of a farm cooperative, and went in the wiring closet of the telecommunications facilities. Few of these were

Figure 2. A cobra killed by local authorities.

planned activities, but rather reactions to opportunities that presented themselves.

Part of being flexible also included planning to have something to do while we figured out how to deal with the unexpected. When we realized that our networking software would not be as helpful as we had hoped, we quickly switched gears to data collection. When our vehicles broke down (on several occasions), we conducted data analysis and worked on our software redesign. Because we anticipated making changes to our software once we reached Zambia and South Africa, our computers were also prepared to be flexible, as they had our software development tools and environment loaded on them. Consequently, we were able to prototype and test an entirely new application in a few days.

Prepare to Find Your Blind Spots

Perhaps the most valuable lesson that we came away with was the realization that, no matter how much preparation we undertook, there were some mistakes that we could not have avoided. We came to call these our "blind spots." Anatomically, a blind spot is the portion of the retina where the optic nerve exits, and there are no cells that allow for sight. This spot is an artifact of the information flow to the brain, and as such, it enables us to see, while at the same time, it limits our ability to see completely. In terms of learning new information, we have cognitive blind spots as well. As artifacts of our current understanding of the world, there exist phenomena that we cannot perceive and comprehend. These blind spots are not the result of willful ignorance or lack of education; they exist as a result of the observer's relation to the world. These cognitive blind spots have been studied in psychology (Schacter, 1999), and they have even been captured in a West African proverb, "The Stranger has big eyes, but he can't see" (Calderisi, 2006). Everyone has blind spots. At issue is how to deal with one's blind spots with respect to doing design work in places distant from home.

An example of a blind spot that we discovered revolved around our relationship with snakes. The Zambians we met had a morbid fear of snakes (and curiously, a relative nonchalance about AIDS not commensurate with the relative death rates). When one of our team nearly stepped on a snake, the locals immediately responded by lighting five acres of their farm on fire. This was shocking to us in the severity of the response. We soon discovered that this was not an isolated response. Throughout the countryside, many acres of nearby fields were burned, ostensibly to drive out or kill a snake, although, possibly, with other beneficial effects unknown to us. One detrimental side effect of field burning was an increase in air pollution. The air was often hazy with smoke for days at a time over a wide area. Before going to Zambia, we had no idea that snakes had anything to do with local air pollution. Had someone told us about Zambian's fear of snakes, we probably would have treated it as a curiosity. But seeing their reaction in context, as well as the network of surrounding consequences, revealed and removed a very large number of blind spots. Furthermore, this knowledge allowed us to brainstorm a software application to improve air quality by tracking snake sightings. With a few extensions to our photo-sharing application, users could participate in a citizen-science-like effort to record locations where snakes were sighted. The density and frequency of these sightings could be aggregated and shared as a "snake signal strength" meter, so people could have more accurate information about dangerous vs. safe areas, so they could focus field burning to smaller areas.

This issue of blind spots is not to be confused with *how* knowledge is acquired. It is clear that if someone had offered us the previous anecdote, we could have understood the relationship between snakes and air pollution. Blind spots are a difficult design challenge because, by definition, we don't know to look for information about them. We were able to discover our blind spots by embedding ourselves with our users. But when designing from a distance for the developing world, even attempting to de-familiarize ourselves (Bell, Blythe, & Sengers, 2005) seems unlikely to illuminate blind spots. The next best option, then, seems to be to acknowledge that, as a designer, one simply will encounter blind spots, and to then prepare to understand the infrastructure around them and be flexible enough to respond.

Blind Spots Are Made Worse by Distance

Distance magnified the challenge of understanding the nature of the setting for which we were designing. It exacerbated our blind spots and limited our ability to collect the data needed for us to do an effective job. Reflecting on our field work enabled us to categorize the ways in which designers become separated from the setting of the users' interactions. In this section, we highlight some sources of distance, broadly understood, that we believe are particularly relevant to HCI4D. Our initial list includes seven categories:

1. *Geographic Remoteness:* The most natural source of distance is geography. A setting can be physically remote, because it is far away or difficult to reach.
2. *Controlled Access:* Designers may be physically separated from interactions due to legal, ethical, or security reasons. Access to sites with confidential information, vulnerable populations, and state secrets are typically restricted to a select few.
3. *Language/Cultural Differences:* A setting may be distant because users and designers do not share a common language or have few cultural commonalities.
4. *Hostility of Environment:* One can be separated from an interaction because it is too dangerous for a designer to study it closely. The dangers can come from concerns with physical violence, health risks, or social hostility. Applications for disease intervention, civil unrest, or toxic environments have settings that fall into this category.
5. *Presence Risk:* Designers can be separated from an interaction setting because their presence can disrupt the interaction or threaten it in such a way as to fundamentally change the practice. People can be distracted while engaged in sensitive practices, and sites can be irreparably disturbed. For example, the presence of a researcher may destroy the meaning of a religious artifact to the practitioners. Conversely, the presence of a designer may cause the interaction to become atypically easier to design for in such as way that, when the designer leaves, the interaction will revert to a less desirable state. For example, observation of street gang behavior by people perceived to be in authority positions might trigger this effect.
6. *Prospective Environment:* Separations can be introduced because an interaction does not yet exist, or because it occurs in unknown locations or those that are difficult to predict. Mobs, crime victims, and pre-diseased patients are examples of users who are difficult to locate before the interaction occurs. Natural disaster sites are difficult to observe during the disaster. Realistic examples of humanitarian aid are hard to find, since, in a given crisis, the aid that actually arrives may be very different than a logistic plan or simulation suggests.
7. *High Cost:* One can be separated from an interaction's setting because the cost of studying the interaction may be too high in monetary terms or the endeavor may require too many qualified personnel.

To illustrate these ideas, consider the inaccessibility of studying the 2004 Sumatra-Andaman tsunami. Prior to the tsunami's occurrence, the area was only a prospective environment, difficult if not impossible to predict. Post-disaster, emergency response workers needed to coordinate and share information with each other. The natural disaster site was remote due to its physical distance, its distribution, and its extent. The site was inhospitable, due to toxic waste and disease in the floodwaters. The presence of the researchers would have been disruptive, because it would take resources away from the relief efforts. Bringing in equipment and supplies was too expensive, and they may not have been available at all. Finally, civil authorities controlled who had access to the disaster area and controlled movement and information flow.

In our case, we also erroneously perceived the distance between ourselves and "Africa" as being greater than the distance between "Zambia" and "South Africa." This perception subtly created in us a belief that we were one type of user, and Africans were a homogenous "other" kind of user. This was our implicit justification for doing initial background investigations with people from places as varied as Sierra Leone and Kenya, even though these were not the environments in which we were planning to deploy our technologies. While we certainly learned a lot from this background work, it did not help our specific design intervention when we had very situated concerns to deal with.

In this sense, distances exacerbate a designer's blind spots, not just by removing interactions from the view of the designer, but also by creating a perception of "us," the designers, and "them," the users, on the other side of the gap. The reality is that there can be as many distances between the different users as there may be between the designers and their imagined target persona.

Conclusion

It is not unusual for technical system designers to have to design from a distance. There is frequently a separation between the people implementing a system and the users for whom the system is being designed. This separation is only magnified when the goals are to explicitly work with underserved populations in the developing world. The distances that separate the designers and users aren't just geographic, although that is certainly part of the challenge. They also include social and cultural distances, which are just as much of a hindrance and are just as magnified. Despite designers' best intentions, they often lack the firsthand knowledge that comes from constant, intimate contact with the people and situations in which their system will be deployed. Conversely, the users, who are the situational experts, have rich local knowledge, but frequently lack sufficient understanding of potential technological solutions to provide designers with the details that would help them produce effective technology. What the preceding case study documents was our acknowledgment that, just as the users do not understand the scope of the technical landscape, designers also have fundamental blind spots that they simply cannot overcome without getting closer to their users.

While this phenomenon is well known to design practitioners, the degree to which working for the developing world magnifies these problems is underplayed. Unfortunately, practical realities mean that there are not always enough resources to do the type or amount of design investigations that are necessary to de-familiarize designers with their view of the situation in order to see the situation in a manner sufficiently similar to their users. When it comes time to deploy the technology, these resources have to be marshaled, and their scarcity means that a lot depends on the success of the deployment. Our conclusion is that, while good iterative, user-centered design practices are as important as ever, it is also critical to be prepared to react when your blind spots are revealed. Systems for the developing world should be designed for maximum flexibility and to work in the presence of a wide variety of infrastructures. Meta-tools are also essential in the preparation for a deployment, so that the infrastructure can be probed and understood. Examples of such tools are Wi-Fi scanners, computer network analyzers, survey creation and collection systems, and various skill-testing suites that enable designers to understand the capabilities and affordances of the socio-technical environment for which they are designing. These tools provide the data upon which design iteration can be successfully and practically executed.

We have framed the lessons we learned in terms of distance, which has caused us to have "blind spots" about the care communities for which we were designing. For us, distance was both literal and metaphorical—not only geographic, but also cultural, social, and conceptual. Reflecting on this insight, we see the motif of distance appearing repeatedly among different people and locales. It appears, most intriguingly, in the software that we ultimately created. The Nomatic*AID application is intended to close the distance between donors and fieldworkers by improving communication and transparency. Not surprisingly, this aims to alleviate a problem that closely paralleled the one that we faced as designers, and that other HCI4D practitioners will likely face in the future. ■

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