COVER FEATURE


# Toward Empowered Design

*Gary Marsden,* University of Cape Town, South Africa

**Pragmatic design requires no radical alterations to the existing digital ecology and has successfully provided many viable solutions. Given the skills limitations within the developing world, however, developers also need a new design focus that views the user as designer.**

Moore's law is a powerful force in the design of digital devices.[1] Because technology becomes cheaper and more powerful over time, digital device designers assume that they will be able to overcome any limitations eventually, as the technology will ultimately become small enough, fast enough, or cheap enough to let developers do what they want. So, from fairly unpromising beginnings, the "tool" of Moore's law can create astounding solutions.

Consider the digital camera, which started as a low-resolution device—such as the Apple QuickTake 100, for example. Originally, devices such as this could capture and store only eight high-resolution images. Current digital cameras have improved to the point they have replaced film cameras for most photographic applications.[2]

Further, websites such as Flickr have proven effective in addressing the problem of how we share and distribute images. Digital photoframes are now cheap enough to have in the home. These frames can automatically and immediately display images taken by a digital camera anywhere in the world that has wireless Internet access.

Yet the power of Moore's law also makes it seductive and can blind developers to alternative design solutions. As my colleague Matt Jones likes to say, Moore's law can be a Band-Aid for poor design: If it doesn't do what you want now, wait for the next release.[3] Therefore, we tend toward solutions that require faster, more powerful hardware becoming available in the near future.

Yet we *can* build creative solutions using old hardware and leveraging more from existing platforms. Powerful as it is, Moore's law need not be the only force driving digital design.

## TECHNOLOGY-POOR ENVIRONMENTS

Most people reading this article will be based in the developed world, where digital technology is prevalent and many people have access to digital devices and electronic services. Bill Gates's dream of one computer per home now seems like a modest ambition; a family needs more than one computer to share. For those of us living and working in the developing world, however, the "personal" computer remains an unrealizable dream.

According to the latest CIA figures, only 12 percent of the South African population—the country in which our research group is based—can access the Internet. Our government has intervened many times to give the wider population access to information and communication technologies (ICT), but most of these attempts have met with limited success: In an International Development Research Centre audit[4] only *one* functioning telecenter was found in South Africa, from a survey total of 63.

This lack of access to ICT has one exception: Some 77 percent of the South African population has computer access via a cellular handset. Given that 50 percent of South Africans live beneath the poverty line, this is a surprising statistic. Yet cellular handsets are popular for many reasons:

- They can survive for days without connecting to an electricity supply. Many rural villages have no access


Published by the IEEE Computer Society

to electricity, and for villages that are connected, the supply is often sporadic.
- Cellular handsets are much less susceptible than laptops or personal computers to environmental conditions such as dust and humidity.
- Unlike a landline, owning a cell phone does not require a physical address. In a continent where temporary housing and migrant working prevail, having a fixed line is next to impossible.
- Given the economies of scale involved, and subsidization by the network service providers, cellular handsets provide one of the cheapest forms of available digital technology.

While there might be a growing number of handset owners in Africa now, is it possible to do anything meaningful in an ICT ecology consisting of a single, fairly primitive, device?

For several years, we have been pursuing an approach we call *pragmatic design*, which creates solutions that do not require adding more technology or infrastructure to a situation. We took the technology in place already—usually mobile handsets—as a given and tried to leverage more from that technology.

## PRAGMATIC DESIGN

To give some idea of what we mean by pragmatic design, we look at two projects we have undertaken and examine how focusing on a fixed device in a fixed infrastructure affected our designs.

### The camera phone

Many people in the developing world now own their first digital camera in the form of a camera phone. When first meeting these camera phone owners, we find that they will use the handset to display a series of images relating to their lives. These images explain the owner's life with everything from pictures of family to minidocumentaries about their work. The story and images are only ever shared in the sense that they are shown to someone else who is using the device that took the original images. There is no PC to download the images onto and no Flickr to use for sharing the images with friends and family—solutions commonly employed in the developed world to store and share images. In this environment, we cannot wait for some new technology to come along and improve the situation; we must design with what we have.

**Storing and sharing images.** Some members of our research group set about solving this problem. First, we decided that the software for searching and managing images on these handsets is insufficient because image collections grow beyond 100 or more photos. Many handsets can store thousands of images, but standard thumbnail browsers are simply too slow to scroll through this many.

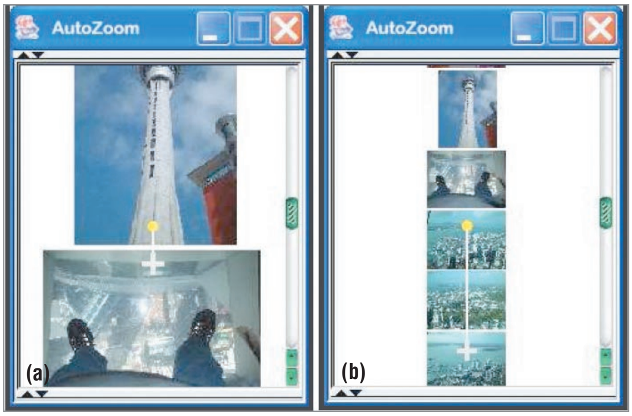


*Figure 1. Image storage and search with autozoom. (a) On the left image, the distance between the yellow dot and the white cross provides a visual representation of the scrolling rate, with the scroll speed low and the photographs large. (b) On the right, the image shows an increased scroll rate with the photographs being commensurately smaller.*

After developing several designs, one researcher implemented a system based on speed-dependent automatic zooming (SDAZ). This system works by scrolling images in a vertical, time-ordered strip in the center of the screen. As the user scrolls faster, however, the images shrink in size, as Figure 1 shows. The smaller size lets the user scroll through the images more quickly.

In our experiments, users could successfully navigate collections of 4,000 photographs.[5] This works because, even though the images are small, there is enough similarity between photographs from the same event to let users identify an event such as a beach trip because it will consist of many images depicting yellow land and blue sky. Thanks to a clever caching algorithm, the software runs smoothly on fairly common handsets—for this application we used a Nokia 6630 from 2004. The software makes it possible to store and retrieve collections of at least 4,000 images on existing handsets, letting us use camera phones as independent image-capture/storage/retrieval devices.

The need to implement such a system came about only because our background studies showed that users who owned only a camera phone would have to manage thousands of images on the handset itself. People who have dedicated cameras and computers should have no need to manage their photos this way. Yet many camera owners who took part in the trial wanted our software installed on their camera phone. Perhaps people in the developed world do not keep many images on their camera phones because the software impedes such use.

**Sharing images.** Another researcher working on our project started to look at the issues around sharing images. Instead of relying on technology infrastructure external to the phone—such as large displays, websites, e-mail, and laptops—he wrote a piece of software for

cellular handsets that lets a user select an image and broadcast it to nearby users' screens over Bluetooth or Wi-Fi. Users could then see the image on their own display and even annotate that image or push one of their images to take part in the interaction.[6]

We evaluated the system using groups of friends who had taken a trip together. These friends then described their day out to another friend who had not taken the trip. We chose this setup to elicit as much social engagement as possible—having several people try to describe the same event simultaneously—to see if the software held up and to monitor if this type of interaction worked or caused frustration. While the software held up to the constant swapping of images, the social interaction proved to be less straightforward.

We had hoped that the experience of using the system would be at least as enjoyable as swapping paper photographs. The actual results proved much more positive. First, the participants enjoyed seeing the photos while simultaneously hearing what they represented; with paper photographs, a listener hears the explanation first, then must wait until the photo gets passed down the line.

Second, what started as a simple show-and-tell rapidly became a highly interactive game, with users doodling on the photo being displayed. The software actually created a new type of social interaction wherein the participants would tease and playfully bait people displaying photographs. At the end of the evaluation sessions, our users refused to return the handsets to us—they were having too much fun using the software.

Again, the design for this system came about to compensate for the lack of Internet access and laptops that prevails in the developing world. Our system lets people with camera phones share their photographs with friends, but without using any more hardware or resources than those they already possess. In pursuing this alternative design, we serendipitously created a new type of social tool that we were unlikely to have found had more technology resources been available to our users.

### E-learning

Being based at an educational institution, we started to think about the paradox the university faced in providing computer facilities to students, when most students had computers already, albeit in the form of cellular handsets. One problem we tackled was that of projectors and networks in lecture theaters. Many teachers have some form of computer, but the cost of a digital projector or network meant that the computer could not be used to display materials during lessons. To overcome this problem, we built a system that would take a PowerPoint slide deck and broadcast the images live across an ad hoc network to any device capable of receiving an image.[7] The network would consist of the teacher's having a Wi-Fi-enabled computer that would broadcast to other devices capable of receiving Wi-Fi.

However, given the low penetration of Wi-Fi cellular handsets, any Wi-Fi-enabled handset would act as a bridge to any Bluetooth devices seeking to receive the broadcasts—Bluetooth handsets being much more common. The system supported students annotating the slide deck with virtual sticky notes, which they could also share with each other, as Figure 2 shows. Again, by doing no more than modifying the software on existing devices, we could solve problems in a way that required no further hardware investment.

### Pragmatic design implications

Our research group has worked on many designs similar to those described thus far, such as viewing chat groups on small screens, porting UNESCO digital libraries to mobile devices, and using mobile devices to track wild animals (www.hciguy.net). However, these were arrived at by rejecting the proliferation of new technologies: the technology-driven design of Moore's law. Significantly, however, these solutions have now found application beyond the developing-world context for which they were intended. For example, both imaging solutions are being developed for commercial release by a North American corporation. Designing for the developing world leads us to innovative solutions less obvious to designers in technology-rich environments, but the solutions are no less valid.

Despite the success of these projects, they are a small drop in the ocean when addressing ICT needs in the developing world. Quite simply, there are not enough people working in this field to create the solutions required. If we are serious about using ICT to improve the lives of people in the developing world, we must empower them to create their own systems. We want to empower people to create systems that can have a positive impact within their own community, without the need for outside intervention. Our research group, therefore, now focuses on investigating a concept we call *empowered design*—our design goal in building any system is that it empowers the end users to modify it to fit their own needs.

## TOWARD PRAGMATIC DESIGN

At first, empowered design might seem like nothing more than open source software advocacy. Certainly, projects like Ubuntu (www.ubuntu.com) are doing much to extend the reach of ICT in developing countries. However, there are few people within Africa who can customize open source packages and shape them into a viable solution.

Rather, we seek to design high-level technology that can be adapted by domain experts to local problems in much the same way as the fourth-generation language movement did in the 1980s.

## NOTICE BOARDS

One challenge we faced in our research was the creation of an electronic notice-board system that would let users select and download content onto their mobile phones. There are many clever solutions to this problem. For example, we could

- use handsets with 3G/Wi-Fi to download content,
- embed material in RFID tags to be read by suitable handsets,
- use ShotCodes or a similar tool to act as bar codes for selecting content on handsets containing the correct software, or
- use a large touchscreen device to select the content and let users enter their details, such as a phone number or e-mail address, so that content could be sent to them.

There are many more possible solutions, and each will work when handsets or display technologies are released with new features that support these interaction types. While only a few people will have such access at the start, eventually this technology will drop in price and everyone will have it.

But this is Band-Aid thinking. Providing local electronic information turns out to be a highly relevant problem in the developing world, one that many people are keen to solve. We have worked with governments, charities, and educational institutions all intent on communicating with people who use their services.

These people, as we know, do not have Internet access so they cannot download information. Nor do they have a PC, so CD or DVD distribution is impossible. From our initial research in this area, we also found that any solution that costs the user money, which requires that they send an SMS or download via GPRS/3G, will also fail. So we must find a way to provide a free, user-selectable download service without relying on a technical solution.

Cell-life (www.cell-life.org.za), an HIV-AIDS charity we work with, came up with the ingenious solution of using missed calls. Imagine that someone wanted information on nearby clinics. The person would dial a specific phone number (each number is associated with a different piece of information) and let it ring. No one will pick up, but the computer captures the number at the end of the connection. That computer can use SMS to return the information at no charge to the requester. Using this system, any clinic or charity can set up a solution for pushing information back to users without their having to invest in new infrastructure or software.

In our case, we are working with an institution willing to invest in interactive notice boards. We wanted users to select content from the notice board's screen

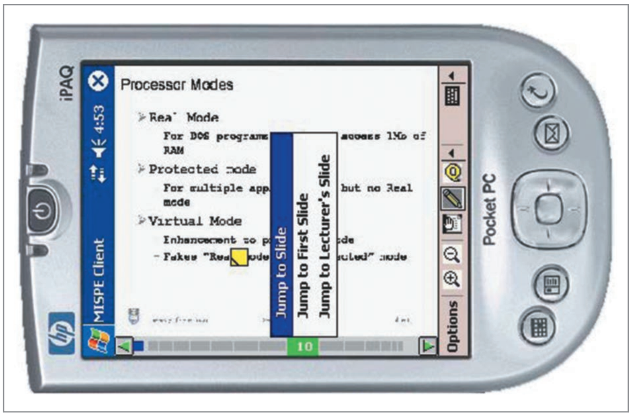


*Figure 2. Annotation with visual sticky notes. In this screenshot of a student's PDA during a lecture, the yellow square represents a note the student has added to the slide. At the end of the lecture, the students can review and share the slides and annotations.*

using their handset. In designing this solution, we had to make sure it did not require any modification of a user's handset and did not cost the user anything.

Starting with the cost issue, we selected Bluetooth as the transmission channel; Wi-Fi would have been faster, but it has yet to achieve sufficient market penetration in current handsets. Prevalent and free, Bluetooth offers a familiar data-transfer mechanism for users in the developing world, so no training in using Bluetooth for this purpose would be required.

The problem with Bluetooth is that it requires pairing before data can be transmitted to an individual device. If there is no pairing, then data is broadcast to all devices in range, resulting in Bluetooth spam. Pairing is a cumbersome process, requiring a PIN entry. It also poses a security risk because any pair of devices has unrestricted access to its partner's data. The problem of how to send data to a single device without prior pairing then remains. Eventually, we circumvented this restriction as a side effect of the media selection mechanism used.

For a selection mechanism, we require that users take an image of the desired content from the screen using the camera on their handset. This image then travels via Bluetooth to the computer driving the screen. The computer runs image-recognition software on the received image and thus decides which information interests the user.

Before the data can be transmitted back to the device, the computer must know the unique ID of the user's handset—the pairing problem. Fortunately, the Bluetooth protocol attaches the sender's ID automatically to any data sent to a device. Therefore the user, in sending the image to the screen, has unwittingly sent the device ID to the computer. The computer can now send the data back to a single handset without spamming other devices in the vicinity. The data—any media such as text, video, or mp3—appears as an MMS from the

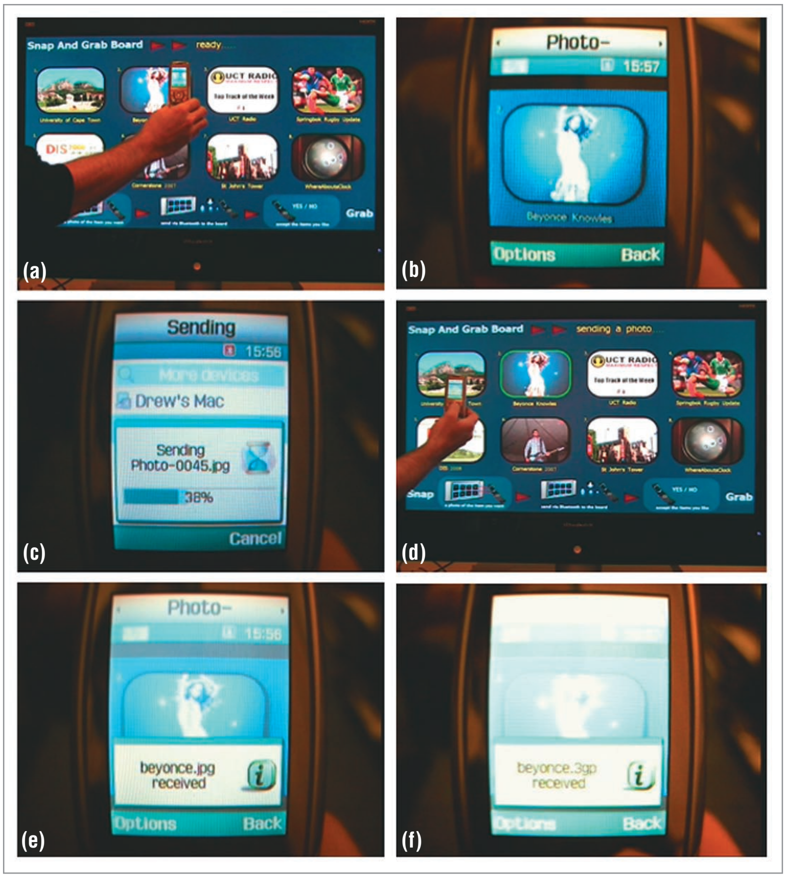


***Figure 3. Interaction series with Electronic Noticeboard: (a) The user holds a camera phone in front of the topic of interest—in this case the singer Beyoncé. (b) The user takes a photo of the desired topic and chooses the phone's "Send via Bluetooth" option. (c) The screen broadcasts its ID continuously so that the transmitting user can find it. (d) Once the image uploads, the computer performs image recognition and highlights the chosen topic by way of confirmation. (e) The user's handset signals an incoming message, and the user sees that she has now received a photograph of Beyoncé. (f) There could be many other pieces of media connected to the selection; here, we see that the user receives a video (3gp) as well as the photograph.***

computer, which the user can handle in the same way as an MMS from any other device. Figure 3 summarizes this interaction.

Therefore, anyone wishing to facilitate communication in any community of use can configure the system. The media is simply aggregated into folders on the notice board computer. Further, the system supports the uploading of media from mobile devices onto the screen, without the need for explicit access to the computer. We envisage this type of system being used in job creation, with artisans advertising their services by uploading a vCard to the screen so that potential employers can download that card to their handset. With this technology, a community can now create an information-exchange system without the need for any programming. They can structure how that information is managed, accessed, and updated without relying on a programmer from outside the community becoming involved.

Thus empowered, a community can now create an information-exchange system without the need for any programming. They can structure how that information is managed, accessed, and updated without relying on a programmer from outside the community.

We are still at an early stage in our exploration of empowered design, but as a research ethos it profoundly influences our group's work. No longer are we, the outsiders, trying to determine the best solutions to a community's needs. Instead, we are doing what we do best—designing technology—but making sure that the community can mold the resulting design rather than forcing the community to mold itself to our design. ■

## References

1. G. Moore, "Cramming More Components onto Integrated Circuits," *Electronics*, vol. 38, no. 8, 1965.
2. *Mobile Imaging Reports*, "Will Camera-Phones Replace Digital Cameras?", 2005.
3. M. Jones and G. Marsden, *Mobile Interaction Design*, Wiley and Sons, 2005.
4. F. Etta and S. Parvyn-Wamahiu, eds., "Information and Communication Technologies for Development in Africa: Volume 2," International Development Research Centre (IDRC), 2003.
5. D. Patel et al., "Improving Photo Searching Interfaces for Small-Screen Mobile Computers," *Proc. Mobile HCI 2006*, ACM Press, 2006, pp. 149-156.
6. L. Ah-Kun and G. Marsden, "Co-Present Photo Sharing on Mobile Devices," *Proc. Mobile HCI* 2007, ACM Press, 2007, pp. 73-80.
7. M. Jones, G. Marsden, and D. Gruijters, "Using Mobile Phones & PDAs in Ad-Hoc Audience Response Systems," *Audience Response Systems*, Chapter 24, Idea Group Publishing, 2005.

***Gary Marsden** is an associate professor at the University of Cape Town. His research interests include mobile interaction design and ICT for development. Marsden received a PhD in human-computer interaction from Stirling University in Scotland. Contact him at gaz@acm.org.*