Towards Empowered Design

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1. Technology Driven Design

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

As an illustration, consider the rise of the digital camera. Originally starting out as a low resolution device, such as the QuickTake 100[1], digital cameras improved to the point that they have replaced film cameras for most photographic applications[2]. Furthermore, web sites such as Flickr have proven effective in addressing the problem of how we share and distribute images. Digital photo-frames are now cheap enough to have in the home; these frames can automatically and immediately display the images taken by a digital camera anywhere in the world that has wireless Internet access.

Yet, because Moore's law is so powerful it is seductive and can also blind designers to alternative design solutions. As my colleague Matt Jones is fond of saying, 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]. We tend to get locked into thinking of technologically based solutions to problems. In the rest of this article, however, we will start to explore how it is possible to build creative solutions using old hardware; how we can leverage more out of existing platforms. Powerful as it is, Moore's law need not be the only force driving digital designs.

1.1 Technology-Poor Environments

Most people reading this publication 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' dream of one computer per home now seems like a lack of ambition; one computer to share amongst a family is not enough. For those of us living and working in the developing world, however, the 'personal' computer is an unrealizable dream.

According to latest CIA figures, only 12% of the South African population (the country in which our research group is based) have access to the Internet. There have been many interventions by our government trying to give the wider population access to ICTs, but most of these have met with limited success (in an IDRC audit[4], only one functioning tele-centre was found – from a survey total of 63 – within South Africa).

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[1] Launched in 1994 by Apple, the QuickTake 100 could take and store 8 high resolution (640x480 pixel) images.

There is one exception to this lack of access to ICTs; some 77% of the South African population have access to a computer in the form of a cellular handset. Given that 50% of South Africans live beneath the poverty line, this may come as a surprising statistic. There are many reasons why cellular handsets are popular, including:

- They can survive for days without connecting to an electricity supply. Many rural villages have no access to electricity and for villages that are connected, the supply is often sporadic.
- Cellular handsets are a lot less susceptible to environmental conditions (e.g. dust, humidity) than laptops or personal computers.
- Unlike a landline, one does not need a physical address to own a cellular phone. In a continent where temporary housing and migrant working are prevalent, it is next to impossible to have a fixed line.
- Due to the economies of scale involved, and subsidisation by the network service providers, cellular handsets are one of the cheapest forms of available digital technology.

Whilst there may now be a growing number of handset owners in Africa, 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 that we called "Sustainable Design" wherein created solutions that did not require any more technology or infrastructure to be added to a situation. We took the technology that was in place already as a given (usually this was mobile handsets) and tried to leverage more out of the technology that was already in place.

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

2. Sustainable Design

2.1 The Camera-phone

Coming back to the digital camera, 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, they will use the handset to display a series of images relating to their lives. These are images explaining the owner's life, everything from pictures of family through to mini-documentaries about their work. The story and images are only ever shared in the sense that they are shown to someone else on the screen of the device that took the original images. There is no PC to download the images onto and no Flickr to share the images with friends and family – the solutions 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 have to design with what we have.

2.1.1 Storing and Sharing Images

Some of our research group set about solving this problem. Firstly, we decided that the software for searching and managing images on these handsets is insufficient as

image collections grow beyond one hundred or more. Many handsets can store thousands of images but standard thumbnail browsers are simply too slow to scroll through this many images. After many designs, one researcher implemented a system based on Speed-Dependant Automatic Zooming (SDAZ). The system works by scrolling images in a vertical, time-ordered, strip in the centre of the screen. As the user scrolls faster, however, the images shrink in size, as in Figure 1. The smaller size allows them to scroll more quickly. In our experiments, users were able to successfully navigate collections of 4000 photographs [5]. It works because, even though the images are small, there is enough similarity between photographs from the same event to allow users to identify an event (e.g. a trip to the beach will consist of a lot of images containing yellow land and blue sky). Due to a clever caching algorithm, the software runs smoothly on fairly common handsets – we used a Nokia 6630 from 2004. This software makes it possible to store and retrieve collections of at least 4000 images on existing handsets, making it possible to use camera-phones as independent image capture-store-retrieve devices.

The need to implement such a system only came about as our background studies that as users only owned a camera-phone, they would have to manage thousands of images on the handset itself. There is no reason why people who have 'real' (i.e. dedicated) cameras and computers should need to manage their photos in this way. Yet many people who took part in the trial who did own a camera wanted our software installed on their camera-phone. Perhaps the reason that people in the developed world do not keep many images on their camera-phones is that the software makes it hard to do so.

Figure 1: The distance between the yellow dot and the white cross is a visual representation of the scrolling rate. On the left, the scroll speed is low and the photographs are large. The image on right shows a greater scroll rate with the photographs being commensurately smaller.

2.1.2 Sharing Images

Another researcher working on the project started to look at the issues around sharing images. Instead of relying on technology infrastructure external to the phone (e.g. large displays, web sites, email, laptops etc.), he wrote a piece of software for cellular handsets that allows a user to select an image and broadcast it to the screens of nearby

users (over BlueTooth or WiFi). 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 been on trip together. These friends then had to describe their day out to another friend who had not been on the trip. We chose this setup to elicit as much social engagement as possible – having multiple people trying to describe the same event simultaneously – to see if the software held up and to monitor if this type of interaction was workable or frustrating. Whilst 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 were much more positive. Firstly, the participants enjoyed seeing the photos simultaneously as their explanation – with paper photographs, one hears the explanation and then has to wait until the photo is passed up the line. Secondly, what started as a '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 bait people displaying photographs. In fact, at the end of the evaluation sessions our users refused to return the handsets to us – they were having so much fun using the software (see Figure 2).

Again, the design for this system came about to compensate for the lack of access to laptops and the Internet that is prevalent in the developing world. Our system allows people with camera-phones to share their images with their friends, but without using any more hardware or resources than those they already possess. However, 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.

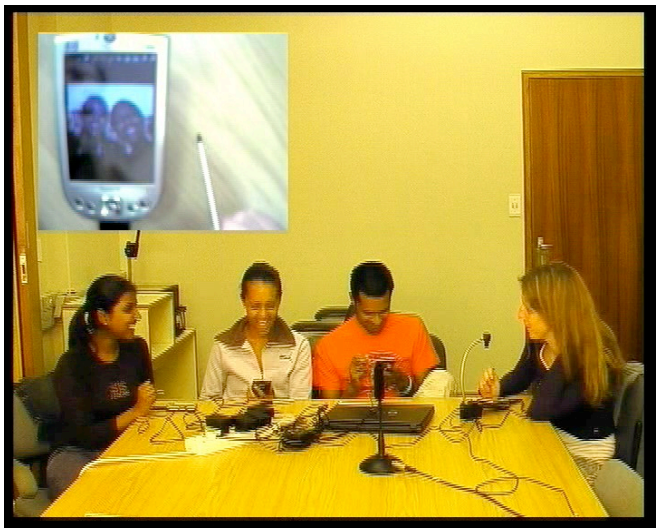

Figure 2: Four friends enjoy sharing their experiences by broadcasting their photographs onto others' mobile devices

2.2 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 theatres. Many teachers have some form of computer, but the cost of a digital projector or network meant that the computer cannot 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 having an WiFi enabled computer which would broadcast to other devices capable of receiving WiFi. However, given the low penetration of WiFi cellular handset, any WiFi enabled handset would act as a bridge to Bluetooth devices wishing 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 (see Figure 3). Again, with no more than modifying the software on existing devices, we were able to solve problems in a way that required no further investment in hardware.

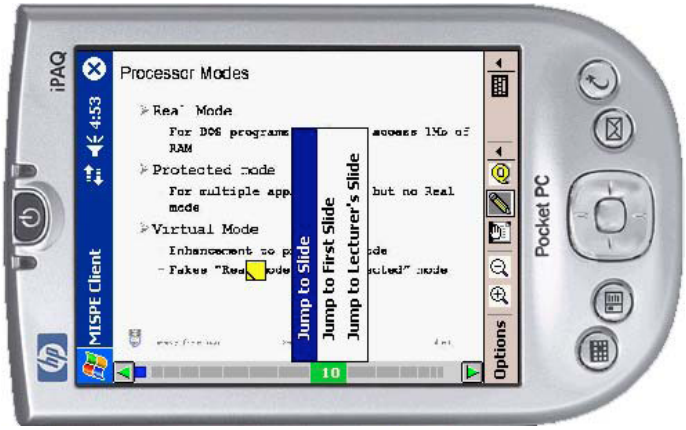

Figure 3: Screen shot of a student's PDA during a lecture – the yellow square represents a note the student has added to the slide. At the end of the lecture, the slides and annotations can be reviewed and shared.

2.3 Implications of Sustainable Design

Our research group has worked on many designs similar to those listed above – e.g. viewing chat groups on small-screens; porting UNESCO digital libraries to mobile devices; using mobiles to track wild animals; etc.[2] However, they were arrived at by rejecting the proliferation of new technologies – the technology driven design of Moore's law. What is interesting, however, is that 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 that are 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 facing up to the needs for ICT in the developing world. Quite simply, there are not enough people working in this field to create the solutions required. If we are to be serious about using ICT as a way of improving the lives for people living in the developing

[2] All our work can be seen at http://www.hciguy.net/

world, we need to empower those people to create their own designs. Our research group, therefore, is now investigating a concept we call "Empowered Design."

3. Towards Empowered Design

At first, empowered design may seem like no more than advocacy of Open Source software. Certainly, projects like Ubuntu[3] are doing much to extend the reach of ICTs in developing countries. However, there are very few people within Africa who are able to customise Open Source packages and to shape them in to a viable solution.

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

3.1 Notice Boards

Let us take an example problem to explore this thinking a little further. One challenge set to us in our research was the creation of an electronic notice-board system that allows users to select and download content onto their mobile phones. There are many clever solutions to this problem. We could:

1. Use handsets with 3G/WiFi to download content
2. Embed material in RFID tags to be read by suitable handsets
3. Use Shotcodes (or similar) to act as barcodes to select content on handsets containing the correct software
4. Use a large touch-screen device to select the content and allow users to enter their details (phone number, email address etc.) so that the content can be sent to them

And there are many more possible solutions and each one of them will work when handsets or display technologies are released with new features that support these types of interaction. Sure, only a few people will have access at the start, but eventually this technology will drop in price and everyone will have access. But this is band-aid thinking.

Providing local electronic information turns out to be a highly relevant problem in the developing world, which many people are keen to solve. We have worked with governments, charities and educational institutions all keen to communicate with people who make use of their services. Theses people, as we know, do not have Internet access (so they cannot download information) nor do they have a PC (so a CD or DVD distribution is out of the question). From our initial research in this area, we also found that any solution which costs the user money (requiring them to send an SMS or download via GPRS/3G) will also not work. So how do you provide a free, user selectable download service without relying on a technical solution? Cell-life[4], an HIV-AIDS charity we work with, came up with the ingenious solution of using missed calls. Imagine someone wanted information on nearby clinics. They 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 number is now captured by the computer at the end of the connection. That computer can SMS back the information at no charge to the requester. Using this system, it is now possible for any

[3] Ubuntu is a popular free Linux distribution originating from South Africa – www.ubuntu.com

[4] www.cell-life.org.za

clinic or charity to set up a solution pushing information back to users without them having to invest in new infrastructure or software.

In our case, we are working with an institution that is willing to invest in interactive notice boards. We wanted users to select content from the screen of the notice board using their handset. In designing this solution, we had to make sure that (a) it did not require any modification of a user's handset and (b) did not cost the user anything.

Starting with the cost issue, Bluetooth was selected as the transmission channel; WiFi would be faster but is not sufficiently prevalent in current handsets. Because it is prevalent and free, Bluetooth is a familiar data transfer mechanism for users in the developing world, so no training would be required on how to use Bluetooth for this purpose.

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 entry of a PIN; it is also a security risk as any pair of devices have unrestricted access to data on their partner. The problem then remains of how to send data to a single device without prior pairing. Eventually we found a way to circumvent this restriction as a side effect of the media selection mechanism we used.

For a selection mechanism, we require a user to take an image of the desired content from the screen using the camera on their handset. This image is then sent via Bluetooth to the computer driving the screen. The computer runs image recognition software on the received image and thus decides which information the user is interested in. 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 ID of their device to the computer. The computer can now send the data back to a single handset without spamming other devices in the vicinity. The data (anything from text, video, mp3 etc.) appears as an MMS from the computer and the user can handle it in the same way as an MMS from any device. A summary of the interaction can be found in Figure 4.

The system can therefore be configured by anyone wishing to facilitate communication in any community of use. The media is simply aggregated into folders on the notice board computer. Furthermore, the system supports the upload 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 whereby artisans can advertise their services (by uploading a vCard to the screen) and potential employers can download that card to their handset. The point is that 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.

4. Conclusion

In this article, we have reflected on the effect that Moore's law can have on the design of digital artefacts. It is not our desire to say that this is wrong per se (the drive from

demanding more performance has had an obviously beneficial effect on technology); rather, that focusing on technology is only one way of designing new solutions.

From our position in the developing world, we started out by examining the notion of sustainable design, wherein we required no radical alterations to the existing digital ecology. This approach proved successful and has resulted in many interesting and viable solutions. Without requiring specialist hardware (and hence incurring cost and specialist attention), the resulting solution will be able to impact a much wider group of people.

However, given the skills limitations within the developing world, we realised that a new design focus was required if we were to have any kind of meaningful impact. This led us to seeing the user as designer.

We are still at an early stage of exploring this notion of empowered design, but as a research ethos, it is having a profound impact on the work of our group. No longer are we, the outsiders, trying to figure out the 'best' solutions to the needs of a community. Instead we are doing what we do best (designing technology) but making sure that the resulting design can be moulded by the community rather than forcing the community to fit with our design.

5. References

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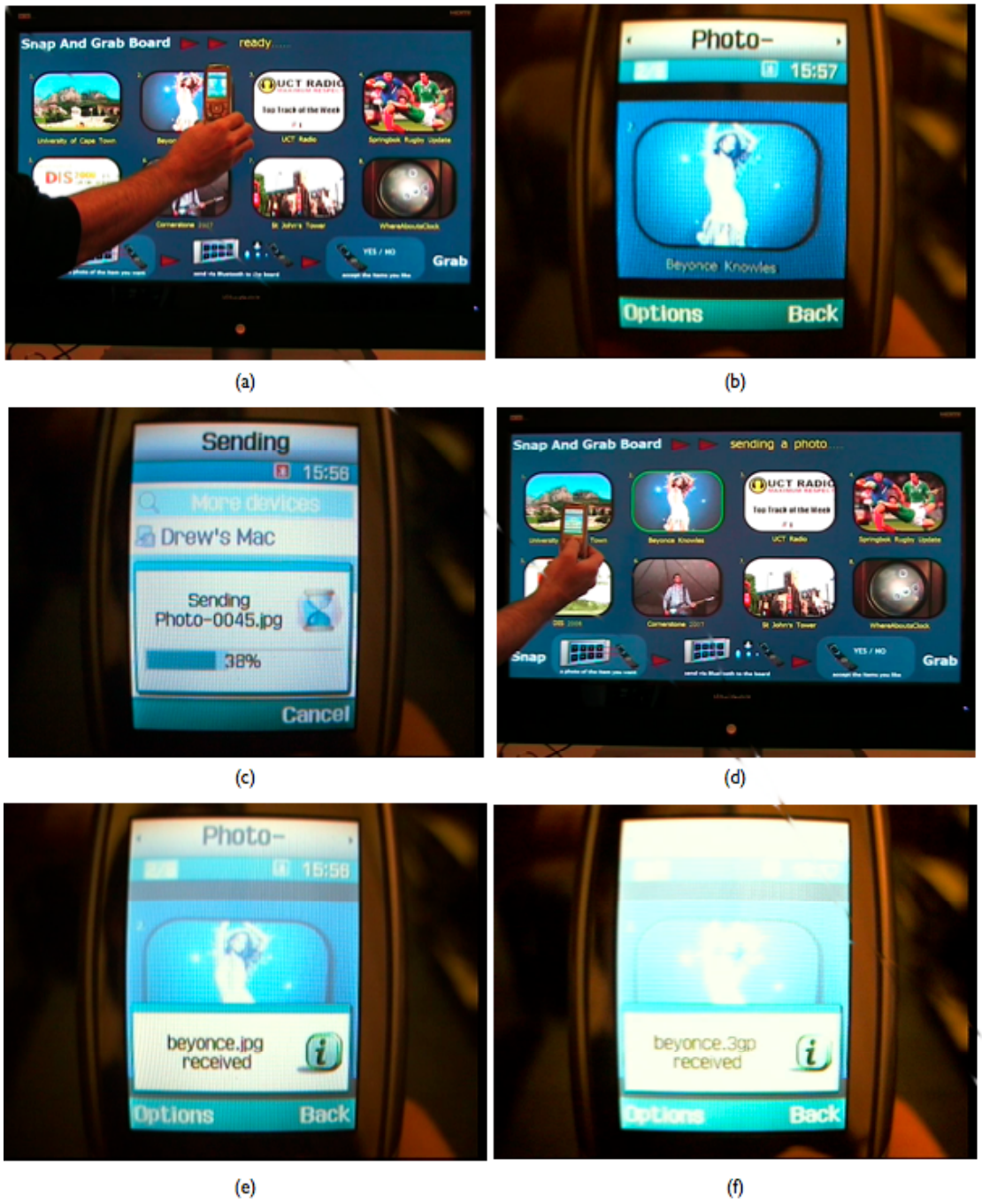

Figure 4 – Interaction Series with Electronic Noticeboard: (a) The user holds their cameraphone in front of the topic of interest (in this case Beyonce); (b) The user takes a photo of their desired topic and chooses the "Send via Bluetooth" option on their phone; (c) The screen broadcasts its ID all the time so can be found by the transmitting user; (d) Once the image is uploaded, 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 they have now received a photograph of Beyonce; (f) There could by many other pieces of media connected to the selection and here we see the user receive a video (3gp) as well as the photograph