Designing an Architecture for Delivering Mobile Information Services to the Rural Developing World

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Abstract

Paper plays a crucial role in many developing world information practices. However, paper-based records are inefficient, error-prone and difficult to aggregate. Therefore we need to link paper with the flexibility of online information systems. A mobile phone is the perfect bridging device. Long battery life, connectivity, solid-state memory, low price and immediate utility make it better suited to developing world conditions than a PC. However, mobile software platforms are difficult to use, difficult to develop for, and make the assumption of ubiquitous connectivity. To address these limitations we present CAM – a framework for developing mobile applications for the rural developing world. CAM applications are accessed by capturing barcodes using the phone camera, or by entering numeric strings with the keypad. Supporting minimal navigation, direct linkage to paper practices and offline multimedia interaction, CAM is uniquely adapted to rural user, application and infrastructure constraints.

1. Introduction

Recently we have seen a growing interest in the *digital divide* - the division between those people that take advantage of digital tools and information services for personal or professional purposes, and those that do not. This has given rise to the optimistic notion that if digitally disenfranchised people adopt information technologies in a sustainable way, they can achieve many development objectives, particularly in rural areas of the developing world. Termed *ICT for Development*, this vision carries a broad and pressing mandate - allowing billions of people access to services as important and varied as health care, education, and financial and governmental services.

During our work with community microfinance groups in rural India, we found that paper plays a crucial role in many local information practices [2]. It is used ubiquitously as a method of data storage, exchange and establishment of trust between two transacting parties. It is a medium that the local people own and trust, and provides a greater sense of security than rented or borrowed appliances. However, the introduction of some technology is desirable. Not only are paper-based processes inefficient, they are difficult to aggregate and do not lend themselves to certain kinds of analyses. This is a serious impediment to information management in developing countries.

The mobile phone has been described as the most likely modern digital device to support economic development in developing nations [4]. As seen in the example of Grameen Phone [1], if a mobile phone is shared by a group of people, it can be affordable for even the poorest communities. New mobile handset models provide an open development platform and significant computing capabilities. Given their popularity with developing world populations, and the immediate utility of voice communications, *smartphones* represent an opportunity to bootstrap computing in the developing world. Several features (battery operation, solid-state memory, wireless connectivity, affordable price) make it a better-suited device for rural developing world conditions than a conventional PC.

However, current mobile software applications are difficult to use, difficult to develop, and often make the assumption of ubiquitous connectivity. To foster an information revolution in the rural developing world, applications must be used by minimally educated users, developed by minimally trained developers and work in a variety of connectivity and power environments. To address these requirements, we present CAM - a framework for developing and deploying mobile applications in the rural developing world. Supporting minimal, paper-based navigation, a simple scripted programming model and offline multi-media interaction, CAM is uniquely adapted to rural user, application and infrastructure constraints.

2. The CAM Framework

The driving element of the CAM architecture is a mobile phone application called the *CAMBrowser.* Users navigate within and between CAM applications by capturing barcodes using the mobile phone camera, or by entering numeric strings. Both can be printed directly on paper forms for ready access. *CAMForm* analogs of existing paper forms serve as offline clients for CAM applications. Data is first entered on paper, from where it is transcribed, validated and uploaded using the CAMBrowser.

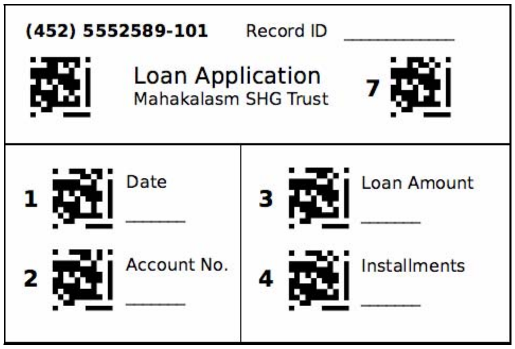

Figure 1. **Part of a CAM-enabled loan application**

3.1. Navigation

In an earlier experiment, we observed the navigation difficulties encountered by semi-literate rural users with a traditional WIMP interface [2]. These problems are exacerbated by the limited display and input capabilities of a mobile phone. Even for literate users, menu-based navigation is complicated, requiring significant time to understand and convey. Moreover, only a limited number of options can be accessed.

To address these limitations, CAM applications and application functions are indexed using numeric strings, encoded either as barcodes to be captured via the camera, or as numbers to be entered via the keypad. Both are printed on paper forms. In this way navigation is directly tied to a paper representation of the task.

3.2. Content

The CAMBrowser downloads and executes applications written in an XML-based scripting language. CAM provides an API for accessing the mobile phone's user interface, networking and multimedia capabilities. Figure 1 shows a loan application designed for a microfinance institution. The barcode in the top right, when clicked, activates a function displaying a sequence of prompts for the user to transcribe the values from the form. The prompts are displayed in sequence rather then arranged spatially, like in a web-based form. This is better suited to the small screen of the mobile device. We call this *wizard* interaction, as it resembles the task wizards used for installing and configuring software applications. Users just choose a high-level task and then follow the prompts.

Each CAM prompt can be associated with arbitrary audio and graphics. This increases the flexibility of the system for dealing with unsupported languages or semi-literate users. The audio contributes to the wizard metaphor, making the interaction proceed like a conversation between user and device. The device asks a question, and the user answers.

After data has been entered, the user can review the values before submitting them to the server. By focusing the camera on a barcode associated with a form field, the current value is displayed on the screen. This reinforces the binding between the written values on the form, and those entered on the phone. If a value is not correct, the user can click on the barcode, displaying a prompt to edit the value.

3.3. Networking

In many rural places, a wireless connection is not available. The first time CAMBrowser encounters an application, it attempts to download the code and data from the server specified in the barcode or numeric string. Using SMS, this request can be issued offline. The SMS is cached in the phone's outgoing message queue. The message will automatically be sent when the phone is connected. When the server receives the SMS, it sends back the appropriate XML code as a MMS message attachment. The phone will automatically download the message when it is connected. The code for the application is cached on the phone for offline use. The next time the phone returns to the village, the application can be used. Application data is stored in the phone's local memory, which serves as a cache of the server database. Data is synchronized using *get* and *put* functions. This is also done asynchronously with messages.

4. Evaluation and Current Work

The true test of CAM is the breadth and relevance of the applications that can be developed. The first CAM application is for data collection from microfinance groups. This application's usability was tested with local field staff in Tamil Nadu, India [3]. Within three days, users could process transaction receipts in an average time of thirty seconds, with an error rate less than 1%. We are starting a pilot deployment covering 400 groups and 24 staff.

We are designing and implementing several other CAM applications. This includes remotely ordering groceries from villages, accessing a patient's electronic medical history, and tracking the movement of goods and people through a rural supply chain.

5. References

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