BRIDGING THE DIGITAL DIVIDE IN DEVELOPING NATIONS THROUGH MOBILE PHONE TRANSACTION SYSTEMS

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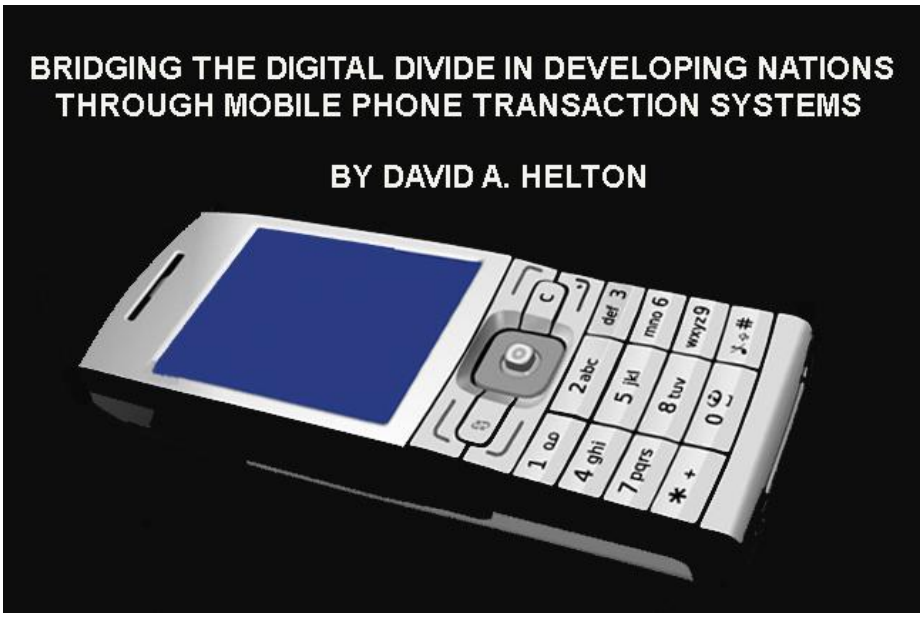

Peer Reviewed

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Abstract

At the apex of the dotcom bubble, philanthropists and government agencies set a goal of bridging the digital divide by bringing internet connectivity to millions in developing nations, principally through personal computers. Reaching their objective in this manner proved impractical where sizeable portions of the population suffer inadequacies in food, medicine, and education, and often lack electricity, telephone lines, potable water, and paved roads.

While the original plan to bring the masses online did not succeed, the market place provided an alternative solution as telecommunications companies expanded mobile phone networks throughout the developing world. The sales of inexpensive handsets soared, creating an information technology infrastructure that connected millions of people who had never before had a telephone. In addition to conventional voice communication and text messages, other usages of the cell networks emerged. Mobile phone transaction systems were one of those experiencing the most growth.

Mobile transaction systems now constitute one of the principle uses of cell phones in countries where most of the people do not have bank accounts and, consequently, no ATM access or debit cards. This article provides an analysis of

features of emerging cell phone transaction systems in developing nations and provides suggestions for their improvement

Introduction

The Digital Divide

During the heyday of the dotcom bubble, the notion arose of a *digital divide*, the disparity between the widespread internet access in industrialized nations vs. the limited connectivity in developing ones (“Technology and Development,” 2005). Development could be accelerated, so the theory went, if internet access became available to the nations with the fewest resources. However, the fallacy with this notion is that it defines the digital divide as the cause of underdevelopment, rather than as a symptom. Healthcare, food, and personal safety are more pressing needs. Notwithstanding, the UN and various non-profit agencies have attempted to open regional computer centers and build internet infrastructures in developing nations, but these efforts have added few new users to the systems. Even Microsoft Chairman, Bill Gates, one of the world’s most generous philanthropists, has focused upon health, rather than technology, in developing nations (“Behind the Digital Divide,” 2005).

Proliferation of Mobile Phones

As companies set up networks throughout developing nations, sales of inexpensive mobile phones (also known as *cellular* or *cell* phones) soared into the millions despite the low incomes of their people (Sullivan, 2007; Jing and Peng, 2010). Very few of these people can afford a sophisticated smartphone, but simple handsets or refurbished ones are widely available for only a few dollars. For those that find even this price prohibitive, creative entrepreneurs make mobile phones available locally for a per-use fee. The handsets offer effective communication in areas lacking extensive networks of land lines and do not need a continuous supply of electricity (“Mobile Telecoms in Africa,” 2011).

Leonard Waverman, Chair of Economics at the London Business School, did extensive research (2005) documenting how cell phones significantly accelerated the economies of developing nations, producing an effect apparently twice as large as that in developed countries. In addition to contributing to economic growth, his study indicated that the growth of mobile phones was a factor in bringing about improvements in health and education. Other research has confirmed the positive impact of conventional mobile communication upon small business in developing nations (Rabayah and Qalalwi, 2011). As important as cell phones have been in enabling voice and text communication in areas which have never had telephone land lines, they also provide other vital functionality.

Mobile phones as connectivity to the internet

Almost overnight, places with no electricity, potable water, or paved roads attained, through the cell phone, not only voice communication, but a mini personal computer with internet access and the functionality to perform business transactions. Sullivan observes that "the social and economic impact of this technology is much more dramatic and disruptive in the developing world, where many people have never had phones before, let alone computers or Internet connections-or bank accounts… The cell phone is not only bridging the digital divide but is changing the way people who have never had bank accounts or credit cards deal with money" (Sullivan, 2007, p. 125).

Marketplace forces provided--through widespread purchase of cell phones--the basic level of internet connectivity in developing countries, an objective which eluded nonprofit agencies and philanthropists. Mobile phones, rather than personal computers, produced a rudimentary internet infrastructure in these nations. Due to limited land line availability, "the cell phone is swiftly becoming Africa's computer of choice" ("Mobile Telecoms in Africa," 2011). Never before has a technological innovation been adopted as quickly as the introduction of cell phones in developing nations. By describing the situation in Africa, where it is estimated 84 million mobiles provide at least elementary internet connectivity, this is illustrated in Table 1 below.

Table 1 Africa: Comparison of Types of Communication Technology in Use, 2011

Technology	**Subscriptions per 100 Inhabitants**
Fixed Telephone Lines	1.4
Broadband	3.8
Computer in Home	7.8
Mobile Phone	53.0*
Source: International Telecommunication Union (2011)	

*Cell phone usage more than quadrupled since 2005, when there were just 12.4 subscriptions per 100 inhabitants

As is indicated by the data in Table 2 below, now a majority of people in all regions of the world have access to cell phones.

Table 2 Global Mobile Phone Usage, 2011

Region	**Mobile Phone Subscriptions per 100 Inhabitants**
Africa	53
Asia & Pacific	74
Americas	103
Europe	120
Source	International Telecommunication Union (2011)

Cell phone transactions

How mobile phones are used for business transactions differs markedly between populations in developed areas versus those in developing regions. In the former, for example, smart phones with complex interfaces might be used as an alternative method to access a personal bank account (Herzberg, 2003). In the latter, simple mobile transactions enable banking-type transactions in regions where few people have conventional bank accounts or ATM access. Thus, it is not surprising that the first commercial mobile payment system began in the Philippines in 1999, and similar transaction systems quickly spread throughout developing nations, where they continue to play a much more significant role in mobile communications than in developed countries (Sullivan, 2007).

Rural regions of developing countries often have few banks, but mobile phones provide the infrastructure for banking. In developing nations, mobile phones provide these financial services: (1) storage of money on the phone and using it as a portable ATM, (2) transfer of funds, (3) purchases and payments, and (4) connections to bank services (Sullivan, p. 139).

Statement of the Problem

Extensive cell phone networks already are in place throughout the developing world. These networks constitute an infrastructure providing clear solutions to many problems associated with building mobile transaction systems. These networks not only exist, but the majority of those in these nations now use cell phones for conventional voice communication and text messages, thanks to the availability of inexpensive handsets and reasonable industry pricing structures. Generally, contracts are not required and handsets feature interchangeable SIM cards that enable usage of one phone for competing IT services. Although many people cannot even afford a handset, most have mobile excess by purchasing the cheap SIM cards, a portable memory chip that makes it easy to switch to a new provider by simply sliding out the old SIM and sliding in the new one. Also, the ubiquitous SIM cards hold some data, something needed in creating mobile transaction systems.

Though present widely-adopted cellular networks supply the requisite foundation, building mobile transaction systems still presents serious challenges in developing nations. One obstacle is the recharging of cell phones, which is difficult in areas where few homes have electricity. Another problem is that users with limited literacy require special interfaces. Also, a large proportion of the inhabitants of these nations have no bank accounts because of limited personal financial resources, banking policy and government regulation. The aggregation of these problems compounds the complexity of building mobile transaction systems in areas with limited electricity, few bank accounts, and scant access to ATM machines. Even issuing a receipt is difficult, for example, where there is no electricity for printing. These very inadequacies, however, have accelerated the development and adoption of mobile transaction systems in these regions.

The objective of this study is to analyze currently emerging mobile transaction systems in developing nations, to delineate salient features, and to determine ones that need improvement. Few studies have focused on rural usage of mobile phones (Donner, 2007), so the special problems encountered in less populated areas are emphasized.

Analysis of Cell Phone Transaction Systems in Developing Nations

Table 3 below lists features analyzed in this paper from various cell phone transaction systems in developing nations. Options are examined for inclusion in a model mobile transaction system (shown later in Table 7) and problems needing to be resolved in the model.

Table 3. Features of Mobile Phones Transaction Systems in Developing Nations

	Feature:
1	**Interface**
2	**Network Type**
3	**Data storage**
4	**Power source for recharging cell phone**
5	**Telecommunications provider**
6	**Financial institution**
7	**Transactions**
8	**Cash in/out**
9	**Receipts**

Interface

Although mobile phone sales have skyrocketed in developing nations during recent years, most units are simple, inexpensive models with restricted interfaces (T 3.1, T = Table). This is because the majority of the people in these nations have low income. Even the simplest units can handle text for transactions, but some cheap models support voice and elementary graphical interfaces.

Medhi, Gautama, and Toyama (2009) studied various mobile payment systems, used by non-literate and semi-literate users, to compare the relative effectiveness of three types of interfaces: (1) text-based, (2) spoken dialog, (without any text) and (3) rich multimedia (with no accompanying text).Their research revealed a strong preference for non-text designs. Tasks were completed more quickly and with less assistance with the multimedia interface, whereas the completion rate of transactions was best with the voice system. They also cite earlier studies, suggesting the benefits of graphical or voice interfaces and simple navigation for users with limited or no reading skills. In extensive field tests (Medhi, Gautama, and Toyama, 2009), none of the non-literate subjects were able to complete any transactions on the text-based

systems, whereas 72 percent had success with voice-based systems, and 100 percent with the rich-client systems.

Despite the results of the aforesaid study, which indicates a strong preference among the less literate for simple non-text interfaces, many of the mobile systems presently deployed in developing nations are text-based (Medhi, Gautama, and Toyama, 2009). For example, Equity Bank's (Kenya) system carries out each transaction as a single text message comprised of specific keywords.Though most present users of mobile payment systems in developing nations studied are literate, test studies demonstrate that with simpler interfaces, the non-literate can perform mobile transactions successfully, especially since most people quickly can attain *numeracy*, the ability to identify numbers and a few other symbols, even if they cannot read or write (Paik and Subramanian, 2009).

The Medhi et al study (2009) describes several interfaces with menus. Globe Telecom's GCash (Philippines) and Safaricom's M-PESA (Kenya) are both based upon the same menu-based interface. The mobile phone produces a hierarchical list of possible transactions from which the user indicates choices with "up" and "down" keys. GCash is available only in English, whereas M-PESA is available both in English and Kiswahili. WHIZZIT (South Africa), though menu-based, requires a USSD message, short code, entered in a specific syntax, made up of digits and other symbols in order to begin sessions and to take actions presented in the menu.

Network Type

There are several types of cellular networks (T 3.2). GSM (Global System for Mobile Communications) developed for 2G (second generation of cell phones, after the original ones) predominates in most of the world except in the United States, where CDMA (Code-Division Multiple Access) is competitive. Key to the popularity of GSM phones is that they usually feature a SIM (Subscriber Identify Module) card, a portable memory chip which can store personal information and other data. The SIM card can activate a phone simply by sliding the card into it. Many people who cannot afford even a simple handset buy SIM cards, so that they can use a local "village" mobile phone. Newer systems of 3G (third generation) and even 4G (fourth generation) networks are emerging within developed nations to accommodate the enhanced capabilities of sophisticated smartphones, but the number of upper-end mobile phones remains low within most developing nations.

Data Storage

In areas with unstable networks data storage (T 3.3) is significant. As noted above, SIM cards of GSM phones provide some local data storage that might be used to record transaction data as is suggested in Paik and

Subramanian (2009). In the case of a network interruption, this would provide a backup until restoration of the internet connection when transaction stored on local mobile unit would be reconciled with official records maintained by the financial institution or information technology (IT) provider.

Power Sources for Recharging Cell Phone

As telecommunications companies have set up extensive cell phone networks throughout developing nations, the scarcity of electricity in many of these areas, a key detriment to effective mobile usage has received inadequate attention. Though some developing nations have high electrification rates, the vast majority of homes in other countries are without any electricity, as is depicted by Table 4 below. Thus, while a trivial factor in industrialized countries, power sources for recharging cell phone batteries (T 3.4) can be a formidable obstacle elsewhere.

Table 4 Electrification Rates in Various Countries

Location	Uganda	Malawi	Tanzania	Kenya	Cambodia	Haiti	India
Percentage of Homes with Electricity	5%	7%	11%	15%	24%	39%	75%
Source	World Energy Outlook, 2011						

Yet, the percent of population with cell access might greatly exceed the electrification area. For example, one half billion people within sub-Saharan Africa have no electricity in their homes. Over 96 percent of the population of Uganda has cell coverage available, but only 5 percent of the people have electricity, the most convenient way to recharge cell phone batteries. At the practical level, the severity of this problem becomes clear. A person might have to walk several hours to find a charging station, which would ask between $0.50 and $1.00 US for this service, in a nation where the annual per capita income is only a few hundred dollars (Harvard School of Engineering and Applied Sciences, 2011).

There are several alternatives for those off of the power grid, but each of these has associated problems. Many inexpensive solar and wind-powered devices for charging cell phones are sold through the internet, for example, but there have been problems associated with their quality and serviceability. Moreover, solar units will not function if it is too cloudy or at night--times when recharging is most convenient. Similarly, wind devices might not work in many locations. A device for charging batteries with a dynamo operated by a hand crank might be more promising.

Finally, there is the prospect of new technologies for recharging cell phone batteries in regions without electrification. For example, researchers at Harvard recently received a grant of $100,000 US from the Bill and Melinda Gates Foundation to develop inexpensive microbial fuel cells to recharge mobile phones. The researchers will go to Africa to test these devices, which can be constructed quickly for less than $1.00 US each because, essentially, they are "dirt-powered" (Harvard School of Engineering and Applied Sciences, 2011). Others are experimenting with cell phone battery chargers powered by bicycles, motorcycles, and the heat from a fire.

Telecommunications Provider

The telecommunications provider (T 3.5) generally would be an IT company. As an alternative, however, the IT department of a financial institution or a government agency might furnish this service.

Financial Institution

Ordinarily, the financial institution (T 3.6) for cell transaction systems would be a bank. Usually this would require that the customer have a bank account. Seventy-five percent of the people in developing nations do not have bank accounts (Kendall, Mylenko, and Ponce 2009), which can be difficult to obtain because of financial and legal requirements. Consequently, these people have no ATM or debit cards. However, some IT companies are providing financial services or the infrastructure for peer-to-peer transactions directly from one cell phone to another without a financial intermediary. Two Philippine companies, Globe Telecom's G-Cash and Smart Communications' Smart Money, are part of a growing number of IT companies that do not require a bank account (Sullivan, 2007).Conceivably, another agency could assume the financial institution's role.

Transactions

In developing nations, the importance of transactions (T 3.7) is surpassed only by voice communications in mobile phone usage. This is in contrast to the situation in developed nations, where most transactions are handled with conventional bank accounts, ATM machines, and credit/debit cards, rather than through cell phones (Sullivan, 2007; Mehdi, Guatama, and Toyama, 2009). As is confirmed by data in Table 5 below, banking by mobile phones is much more commonplace in developing nations than in the rest of the world.

Table 5 Percentage of Cell Phone Users Engaging in Mobile Banking, 2010-2011

Nations	France, Germany, Italy, Spain, UK	USA	South Africa	Kenya
Mobile Banking	8.5%	14%	37%	38%
Source	Clark, 2012	Lenart and Frederiksen, 2012	World Wide Worx, reported in Clark, 2012	Jack and Suri, 2012

Payments are one of the most common types of transactions. For example, very few businesses in Africa accept credit cards because of the fees involved and the instability of electricity, but mobile phone payments are beginning to fill this void (Sullivan). Coca-Cola distributors in Zambia began paying for deliveries of inventory through text messages through mobile phones, rather than handling large amounts of cash in a nation where few people have bank accounts. Customers made similar mobile payments for routine purchases at dry cleaners, petrol stations, stores, and restaurants ("Calling across the Divide," 2005). In Haiti, the international aid agency, Mercy Corp, recently began testing the proMobile system to make payments to workers in its cash-for-work program developed after the January 12, 2010 earthquake (Sossouvi, 2010).By using a short sequence of commands on their cell phones, a person can make purchases, pay a beautician, or hire a taxi.

ProMobile is an example of the many systems permitting inexpensive transfers of money to others. This avoids the high fees charged for conventional transfers by such companies as Western Union.

In developing nations, banking systems accessible through cell phones usually enable deposits and withdrawals. How funds are accessed varies. This will be considered in the next section.

Cash in/out

The lack of bank accounts and ATM access in many regions of the world is in marked contrast to their ubiquity within developed nations, as evident in Table 6 below.Therefore, cash in/out (T 3.8), i.e., access to money, is a critical consideration. Mobile phones provide the banking infrastructure to make this possible (Sullivan, 2007).

Table 6 Percentage of Population with Bank Accounts, 2010

Location	Sub-Saharan Africa	Pakistan	All Developing Nations	Developed Nations	Belgium & Netherlands
Bank Accounts	17%	<20%	30%	81%	>98%
Source	Ondiege, 2010	Kendall, Mylenko, and Ponce, 2010			

One of the most commonplace features of mobile banking systems is to create credits/debit-- in effect, digital money that may be used in subsequent internet transactions. Handling cash transactions is more challenging.

Cell transaction systems frequently are tied to bank accounts, so mobile customers may make deposits or receive cash at a bank office if the individual can travel to it. Similarly, cell phone customers with bank accounts could use an ATM to receive currency, but very few ATM locations exist in some countries.

Some financial institutions are using cell phone accounts as a stepping stone to qualifying for regular bank accounts. MTN Banking (South Africa) issues ATM cards, upgradeable to a debit cards, to its cell phone system customers even if they do not have a bank account. Competitor WIZZIT, in the same nation, issues its mobile phone users debit cards to use at ATMs and merchants even though it is a virtual bank with no branches (Sullivan, 2007).

In place of ATM withdrawals, Mercy Corp's mobile wallet (Sossouvi, 2010), a veritable banking system on a cell phone, may be used at convenience stores to transfer money to the cashier, who returns the appropriate amount from the cash register to the user. The mobile wallet appears to be well receive, in a country where few people have bank accounts and, therefore, no access to ATMs. Haitians testing the system feel it is a good alternative to banks for storing money safely and promoting saving. Recently, Voila Comcel, a Haitian mobile phone company, and Haitian Unibank implemented the T-Cash mobile money service (Trilogy International Partners, 2010), a commercial system based upon that piloted by Mercy Corp.

Receipts

Providing receipts for cell phone transactions (Table 3.9) has been challenging in developing nations. Several methods are used and improvements have been suggested.

In developing nations, paper receipts have been the standard because of unstable connectivity in networks (Paik and Subramanian, 2009). Paper receipts, however, are vulnerable to wear, loss, and falsification.

Notwithstanding network instabilities, various systems use text messages for receipts, such as WHIZZIT (South Africa), Globe Telecom's GCash (Philippines), and Safaricom's M-PESA (Kenya), each described in (Mehdi, Guatama, and Toyama, 2009). Another example is a proposed mobile ATM (Karunanayake, Zoysa, and Muftic, 2008).

Recent research (Paik and Subramanian, 2009) suggests a prototype system for storing receipts reliably on the cell phone's SIM card. However, implementation of this system has not yet occurred.

Proposed Model for Mobile Phone Transactions

As a result of the foregoing analysis of features from various present cell phone transaction systems, certain salient options are included here for a proposed model for these systems in developing countries is revealed in Table 7 below and remaining problems needing attention are discussed.

Table 7. Proposed Model for Mobile Phone Transactions in Developing Nations

	Feature	*Options*
1	**Interface**	text or voice/graphic
2	**Network Type**	GSM
3	**Data storage**	SIM card and financial institution/IT company
4	**Power source for recharging cell phone**	hand crank or other new technologies, electrical outlet
5	**Telecommunications provider**	IT company or other agency
6	**Financial institution**	bank
7	**Transactions**	payments, transfers, deposits, withdrawals
8	**Cash in/out**	credits/debits, local store, local agent, ATM
9	**Receipts**	text messages or storage on SIM card

Interface

There are compelling reasons for supporting two types of interface (T 7.1, T = Table) in developing nations. Most of the people there can afford only simple mobile phones, which most readily support transactions through text messages. Thus, a text interface is an essential option, though usable only by those who are literate. This is confirmed by the research of Medhi, Gautama, and Toyama (2009). An alternate, non-text interface--voice, graphic, or a combination of these media--is required for the millions of people in remote locations that cannot read.

Network Type

The standard network type (T 7.2) in most of the world is GSM. This is at least partly due to its SIM cards, which make it easy to switch from one handset to another. In rural areas of developing countries, more complex networks are not yet available.

Data Storage

Due to the instability of networks in many areas, transaction data storage (T 7.3) on the local cell phone SIM card is an attractive alternative to online storage at a remote institution or company, especially as a backup when connectivity is not available. Nevertheless, the main storage should be maintained by financial institutions or telecommunications providers with systems adequate to preserve transaction information.

Power Sources for Recharging Cell Phone

A satisfactory power source for recharging cell phones (T 7.4) is a formidable obstacle in many developing areas of the world to conducting transactions via mobile phones. As was observed earlier, there is widespread mobile network availability in many areas where very few homes have electricity. Rural areas, off of the power grid, have not had inexpensive, effective alternatives for charging cell phone batteries. Thus, the best prospects for them would be hand crank dynamos and other innovative chargers that are in development that are powered by energy sources such as open fires, bicycles, motorcycles, and microbes that live in dirt.

Recharging cell phones is much less of a problem in major cities, even in the developing world, because electricity is available at home or somewhere nearby. However, many metropolitan areas in the developing world suffer frequent power outages and, consequently, customers might, nonetheless, want to buy an inexpensive alternate type of charger.

Telecommunications Provider

In the model, the telecommunications provider (T 7.5) normally would be an IT company or the IT department of a company. Private or government agencies also might provide this service, especially in areas with low per capita income.

Financial Institution

The financial institution (T 7.6) for mobile transaction systems ordinarily should be a bank or equivalent institution. Some IT companies are assuming banking roles, but that is not their area of expertise. Even where telecommunications companies provide infrastructure for peer-to-peer transactions between two cell phones, the system should be more trustworthy

with a banking intermediary. In rural areas of developing countries, other agencies may furnish financial services, though this should be viewed as a temporary expediency.

Transactions

As was noted earlier, banks and cash machines are rare outside of major cities in these countries. Even in their cities, the majority of the people typically do not qualify for bank accounts and accompanying ATM cards. Thus, many of those residing in both rural areas and cities rely upon cell phones for everyday banking transactions (T 7.7)--payments, transfers, deposits, withdrawals. Mobil phone payments can substitute for credit and debit cards in making purchases or paying for services.Instead of using costly Western Union services, transfers may be made between mobile phone users. A company may send a paycheck as a deposit to a cell phone account.The way withdrawals are handled varies, depending on whether electronic credits or cash is involved, as is described in the following section of this paper.

Cash in/out

For those in remote areas, as well as for urban dwellers without bank accounts, mobile transaction systems need to provide mechanisms for cash in/out (T 7.8), i.e., depositing and receiving cash. These systems can issue credits/debits which function as digital currency for future transactions. In isolated areas special cash registers at local stores or other agencies can receive and send text messages to cell phones that permit cash deposits and withdrawals on the spot (Sossouvi, 2010).

A new development offers promise in handling cash to those living in cities without bank accounts. Even though laws and banking conventions have blocked a large percentage of urban dweller in developing countries from having bank accounts and accompanying debit cards, mobile accounts are beginning to bridge the gap, enabling some access to cash deposits and withdrawals at bank branches and ATMs.

Receipts

Businesses in cities usually have the electricity needed to print receipts, but this is a problem in many rural areas. Although financial institutions software tracks mobile phone transactions, users in remote areas with unstable connectivity still expect receipts (T 7.9) as confirmation. An analysis of several current systems suggests that text message receipts provide an adequate solution. As a backup to reassure users, a prototype of storing receipts locally on the user’s cell phone SIM card (Paik and Subramanian, 2009) might provide a future alternative.

Conclusions

This study documented the heavy reliance within developing countries on mobile phones to carry out business transactions that are handled much less frequently by cell phones in industrialized nations. In the developed world, ubiquitous access to banks, ATMs, credit cards and personal computers diminish the need to complete transactions through mobile phones. However, the lack of access to these amenities within the developing world has resulted in extending cell phone functionality beyond ordinary voice and text communication to include transactions involving banks and other businesses.

Notwithstanding the intense usage of mobiles for business transactions, these systems present unique challenges in developing nations. In this study, various features of present mobile transaction systems were examined to identify the best existing features and those that need improvement. As a result, outstanding current features and suggested enhancements were amalgamated into a proposed model for improved mobile phone transactions systems in developing nations.

Features of the model needing further study include: (a) interface (T2.1)—simple graphical ones needed for people with limited literacy, (b) data storage (T2.3)—in areas with frequently interrupted transmissions, temporary storage of transactions needed on local mobile phone, (c) power source for recharging cell phones (T2.4)—new alternatives needed where electricity is unavailable, (d) financial institution (T2.6)—lack of bank accounts, as related to bank policy and government regulations, and (e) receipts (T2.9)—since paper printing is problematic in areas without electricity.

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