eKichabi: Information Access through Basic Mobile Phones in Rural Tanzania

Galen Weld[1], Trevor Perrier[2], Jenny Aker[3], Joshua E. Blumenstock[4], Brian Dillon[2], Adalbertus Kamanzi[5], Editha Kokushubira[5], Jennifer Webster[2], Richard J. Anderson[2]

[1] Cornell University, [2] University of Washington, [3] Tufts University,
[4] University of California Berkeley, [5] Institute of Rural Development Planning Tanzania

gcw33@cornell.edu, tperrier@cs.washington.edu, jenny.aker@tufts.edu, jblumenstock@berkeley.edu, bdillon2@uw.edu, adalbertus.akamanzi@gmail.com, kokushubiraeditha@gmail.com, jenniweb@cs.washington.edu, anderson@cs.washington.edu

ABSTRACT

This paper presents eKichabi, a tool for retrieving contact information for agriculture-related enterprises in Tanzania. eKichabi is an Unstructured Supplementary Service Data (USSD) application which users can access through basic mobile phones. We describe our focus groups, a design iteration, deployment in four villages, and follow up interviews by phone. This work demonstrates the feasibility of USSD for information access applications that have the potential for deployment on a large scale in the developing world. From user interviews, we identified strong evidence of eKichabi fulfilling an unmet need for business related information, both in identifying business contacts in other villages, as well locating specific service providers. One of our key findings demonstrates that users access information through multiple modes, including text search, in addition to menu navigation organized by both business sector category and geographic area.

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces

Author Keywords

ICT4D; HCI4D; Basic Mobile Phones; USSD; Tanzania.

INTRODUCTION

In the developed world, the introduction of digital and network technology has transformed information search. However, this transformation has yet to occur in much of the rural, developing world, where most people have limited access to digital information sources. Here, we report the results of a study in rural Tanzania designed to better understand the process of expanding people's ability to look up digital information. Specifically, we developed and deployed a new mobile phone-based system to help people search and browse for the phone numbers of nearby businesses – in essence, a USSD-phone yellow pages. The work was guided by two core principles: the tools provided to people must match the available infrastructure, and the information being sought must have recognized value to the people who access it.

This work capitalized and expanded upon an earlier effort by Dillon et al. [10], which found that a simple paper-based phone directory helped farmers connect with nearby villagers, and generated new business for small-scale agricultural enterprises. We used the information on local businesses collected through that effort to seed a phone-based directory, and worked with the same trusted community contacts for piloting and focus groups.

We elected to generate the directory for use on basic mobile phones because, while the prevalence of smart phones is increasing rapidly in urban Africa, basic phones continue to dominate in rural regions. In addition, while the paper version was quite popular, it would have been prohibitively costly to significantly scale up the production and dissemination of a paper-based directory. We made a significant design choice to build the application on Unstructured Supplementary Service Data (USSD), a carrier level protocol available on all GSM phones. While USSD is common for first-party carrier and mobile network operator (MNO) applications as well as second-party banking applications, it is rarely used in third-party applications such as ours [26]. Thus, one of the contributions of this work is to demonstrate the technical feasibility of a third-party USSD application.

This project developed and introduced a USSD based phone directory in four districts of the Dodoma and Manyara Regions of Tanzania, where users could search for business information in our database. A prior project, *Kichabi,*[1] had developed and deployed a paper based phone directory for the same area. This

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[1]The name is from the Swahili *kitabu cha biashara* or "business book," hence our choice of *eKichabi*.

project was developed by a team of development economists interested in understanding how directory information would increase the volume of business interactions and income [10]. One of the motivations for the development of eKichabi was to have a version of the business directory that could be taken to scale as the cost of distributing the phone book, including updates, limited its distribution to the initial study area.

Field work for this paper began with an assessment of a USSD application with focus groups (17 groups, 57 total participants). Based on feedback, we revised the application, and deployed it in 4 villages with 107 registered participants, logging the results of 1,883 usage sessions. We conducted follow-up interviews with 65 participants by phone. All field work took place in rural Tanzania, and involved local research assistants who spoke Swahili, and had connections with the participating villages.

In this project, we aimed to evaluate a mobile phone application for information access intended for use by people in rural areas of Africa. We also sought to understand how people used the application and to identify barriers to use. Since this was an initial deployment of an application, we emphasized *feasibility*, *usability* and *acceptability*, attempting to answer questions such as:

- Is USSD a suitable technology for deploying a search- and browse-based information service in rural Tanzania?
- How well can the target users search for phone numbers, and what are the approaches users take to find a number?
- Does the electronic version of the phone directory meet people's needs, and is it something they will use on a day to day basis?

To our knowledge, this is the first study to directly address these questions. A growing body of literature investigates the human-mobile interface in developing countries, and a number of studies attempt to measure the socio-economic impacts of mobile phones, but our focus is somewhat different. We are interested in understanding how to effectively provide a new information service to individuals in rural Africa. This service is intended as a complementary good to existing mobile phone networks, to help people access information and communicate with others who in theory are at their fingertips, but in practice are currently just out of reach.

RELATED WORK

This work is situated in the HCI4D literature [9], which is broadly focused on expanding access to information technology to under served regions. As mobile phones are the primary means for digital access available to people in developing regions, this work draws heavily on the literature of mobile phones for development [11].

USSD

A key tenet of this work is that technology equity requires a focus on infrastructure available to a a significant majority of users. In our setting this means basic mobile phones and SMS, IVR or USSD services. We chose USSD as our implementation technology, following the advice of Wyche: *Designers need to focus on developing mobile applications using the Unstructured Supplementary Service Data (USSD) protocol for the basic and unsexy mobile phone we observed* [35]. In spite of this suggestion, discussions of USSD technology appear infrequently in the computing literature. We utilize the work of Perrier [26], who developed a framework for building USSD applications. USSD has been an important technology for implementing mobile money systems [15], and is utilized increasingly in projects that support government services such as MSeva in India[17]. Eagle reported using USSD for txtEagle, a crowdsourcing tool for basic phones [12].

Other technologies for information applications targeting basic mobile phones include Short Message Service (SMS), Interactive Voice Response (IVR), and SimApps [14]. While we did not rely on these technologies, we were informed by works addressing similar usability challenges [5, 21].

Mobile Phones

There is a rich literature describing the challenges associated with mobile phones in developing countries, including cost of phones, charging phones, maintaining airtime, repair, and coverage [1, 36, 32].

Prior work studying mobile phone use in rural Africa is particularly relevant to our work, including papers by Odour [24] and Wyche [33] in Kenya, Martin [20] in Uganda, and Steinfield [29] in Malawi; the background conditions they describe are generally consistent with what we observed in rural Tanzania.

Our project is also motivated by work to estimate the causal effects of mobile phones on social and economic outcomes [4, 3]. Early work by Jensen [16] and Aker [2] showed how the expansion of mobile phone networks facilitated the flow of information about prices between rural producers and consumers. More recently, an accumulating body of evidence indicates that other technologies delivered over the mobile network — and in particular a recent suite of rudimentary financial services [30] — are also improving long-run welfare. Aker et al. [3] provides a recent review of research on the economic impacts of mobile phones in Africa.

Information Seeking

A long range vision for this work is to support broader information access such as one finds in on-line directory services. However, this work is in an early phase, focusing specifically on access to business phone numbers. There have been a number of research efforts looking directly at implementation of Yellow Page services. Kopparapu [18] argues against IVR for yellow pages, and presents a SMS yellow pages services. The main focus of that work was on NLP techniques for understanding queries. There is also a literature on yellow page queries [19] which focuses on issues of classification or spatial location that are beyond the scope of our current directories.

Work on information seeking targeting low resource settings has considered general issues of usability and low literacy. USSD and SMS interfaces have been considered by Medhi [22]. SMS has been studied as a general interface for web search by Chen [7] and there have also been projects at

Google [28] and Yahoo! [37] for SMS web search. Multiple researchers have looked at agricultural information systems [3]. The most common version of an agriculture information service is push SMS messages, although studies have shown these have limited impact [6, 13, 34] and face-to-face communication is still a major source of information [8]. Other examples of projects specifically involving search for information include Patel [25] who developed a voice based forum for farmers, and Medhi-Thies [23] who looked at a custom social networks.

BACKGROUND

We now present background to give context for our work. We begin with a brief description of our implementation area in the Dodoma and Manyara Regions, Tanzania. This is followed be a brief summary of the initial Kichabi project that introduced the original paper phone directory in the study area. We then discuss USSD technology, and give our reasons for adopting USSD for the implementation of eKichabi.

Project Area

The project took place in a rural area of roughly 5,000 square miles, northeast of Dodoma, the capital of Tanzania. The area consists of semi-arid plains with some forested areas. The population is primarily agricultural, with main commercial crops of maize and sunflower, supplemented by household crops such as beans and cassava. People involved in farming often derive some income from supplemental business activities. The population is distributed in villages connected mostly by unpaved roads. Approximately 9% of households are connected to the electrical grid. Of particular interest is cellular coverage, where essentially all villages have some access. Airtel, Voda and Tigo are the major operators in this part of Tanzania, with Airtel having the largest market share, and the other two being well represented. The common situation in a village would be to have partial coverage by one or more provider with known locations with better coverage. People had widespread access to basic mobile phones, but smart phones were rare. For example, of the people in the focus groups (discussed below), 85% had access to a basic phone, 12% had access to a smart phone, and 3% did not have phone access. The observed access to cell phones was in line with other published accounts [24, 29, 33] and made us confident in developing applications targeting basic mobile phones.

Kichabi Project

The initial Kichabi project was a 28-month study [10] to investigate the economic impact of introducing a mobile phone directory of businesses associated with agriculture. The underlying theory was that personal networks only allowed a limited number of contacts, and the introduction of a directory service would expand individual networks, increase the number of business interactions, and eventually increase incomes. The project began with a census of agriculture-related enterprises in the study area. A directory was created listing 1495 enterprises, organized by village, sector[2], subvillage and business name. Since many of the businesses were informal, it was necessary to create or normalize names as part of the registration. The 39-page paper directory was then distributed to selected households.

[2]Sector refers to the type of business, with categories: retail, wholesale, repair, agriprocessing, service, transport, hiring, and financial services.

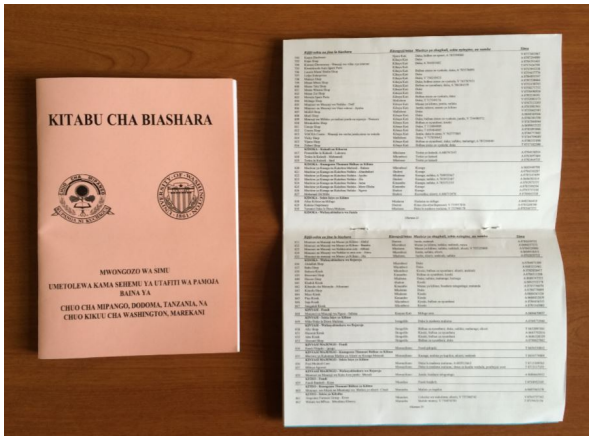

Figure 1. Original paper *Kichabi* directory, with 39 pages listing 1495 businesses, distributed in 2015.

The project was designed as a randomized control trial (RCT) to study both the effect of listing businesses and distribution of directories. Control and treatment groups were determined for both business listing and directory distribution for the study. (After the study was completed, a second printing listing all businesses was distributed.) The study showed suggestive evidence of enterprise outcomes, and statistically significant impacts on measures such number of contacts and probability of sending mobile money. For details on the findings, see [10].

USSD Applications

USSD is a protocol available on the GSM network that allows the creation of simple, text-based interfaces. USSD is session based, meaning that a connection between the user's phone and the service provider is maintained until explicitly ended by the user, or until the session times-out due to inactivity. During a session, a series of text-only screens (160 characters or less) are displayed to the user, who can respond with input text responses. USSD has a number of advantages over SMS: message delivery is often much faster, and ordering of messages is guaranteed. Since USSD maintains a session, it is possible to have stateful interactions with a server. USSD is also considered to be more secure than SMS. A primary use of USSD is to implement carrier level operations, such as checking a balance, or adding airtime credit from scratch-off cards purchased from a vendor. A second common use of USSD is to implement mobile money products where a USSD application is used to send money between accounts linked with SIM cards. In both of these cases, the USSD application is controlled by the carrier.

The major obstacle to implementing third party USSD applications is restricted access due to control by the carrier. Typically implementing a USSD service requires lengthy negotiations with individual carriers. An important recent change is that gateway services, who previously bundled SMS services, have

begun offering USSD products as well. It is now possible for smaller projects to use a USSD number provided by these gateways for their own applications. The existence of a USSD gateway for Tanzania enabled the work described in this paper. The number of third party USSD providers has greatly expanded in the last few years, with stable gateways available in Kenya, South Africa, and Nigeria.

The primary building block of most USSD applications is the numbered menu, where each menu item is on a separate line, which begins with an index number. To make a selection, the user responds with the index number corresponding to the desired menu item. The back end server both processes the text received and returns the next menu to display. This makes it straightforward to display dynamic menus or lists of items to select from. Since the third party USSD provider we are using exposes a simple HTTP API, the eKichabi application is implemented as a text based webpage. This was developed using Python, Django, and the UssdHttp library developed by Perrier et al. [26]. Additional development of menu and search UI elements was done by the authors.

We determined that USSD would be an appropriate technology for this project based on our prior understanding of the study area. Reasons for choosing USSD included: a USSD application would be available to almost all people because of the availability of basic mobile phones and cellular coverage, a session based protocol supported multi-step operations, the population would likely have some experience with USSD applications through use of mobile money, and we would be able to get a USSD gateway and short code. We also ruled out the competing technologies for a number of reasons. SMS was not used because of the difficulty of creating textual queries and the cost and complexity of multi-round queries. IVR was not used because of the time and complexity of of navigation using voice. Smartphones were not an option because of their low market penetration in the region. Finally, a pair of technologies, SIM apps (where the application resides on the SIM card) and overlay SIMs (where the application is on additional hardware attached to the SIM) we not used because of difficulties in distributing custom hardware.

Our choice of USSD over SMS is particularly significant, as many computing for development projects targeting basic mobile phones have been based on SMS. There are two common styles of SMS application: one is based on sending a textual query to a server and receiving the result, and the other is to simulate a menu based interface by sending single character commands. SMS applications which require a special syntax for queries are very error prone [27] even when workers receive training on their operation. The multi-round SMS interfaces suffer from message delays, and the cost of multiple messages. Wyche [34] has an important analysis of challenges faced in rural Kenya on the use of SMS applications.

EKICHABI APPLICATION

The eKichabi allows a user to look up a phone number stored in a central directory. The application is accessed by dialing a short code such as, *123*45#, which brings up the main menu. Three browsing modes are provided: browse by location, browse by sector, and search. Figure 3 shows a sample

Figure 2. eKichabi main menu accessed via USSD on a demo handset from the Phase 1 focus groups.

session, in which a user browses by location to find a business, stepping through two levels of the geographic hierarchy before selecting the business. The browse by sector option behaves similarly, except the the first screen prompts to select a business type, before navigating through a geographic hierarchy or getting a list of businesses. When there is an option of seeing a list of all businesses matching the query, the number of businesses is displayed, to help guide the user whether or not to further refine their search. Many menus have too many items to fit within the 160-character confines of a single screen. In this case, as many options as fit are presented, and the remaining items are folded into another page of menus, under the heading "0. next". The system creates as many pages as needed to display all menu options. The menu also provides an option to go back, which is given the special index number of 99. This back option can be selected from any screen, not only a menu screen, and its functionality is explained to the user on a help screen available in the main menu. The application supports both English and Swahili text; the deployment in Tanzania used the Swahili version exclusively.

Search

The third menu option offers a search-based interface. Upon selecting it, the user is presented with a sub-menu, asking if they would like to search for a district, a village, a subvillage, or a business. After making this selection, the user is prompted to enter the first few characters of the name of the location or business for which they are searching, and a prefix match is done. If the query matches only one location or business, the user is taken directly to the associated page. If the query returns multiple possible results, the user is taken to another menu where they're prompted to select from the possibilities.

This search functionality was developed through several iterations, incorporating feedback from focus groups. Prior search implementations attempted to determine what the user was searching for (a business name, or village name, etc.), and return any result containing the query, regardless of its position in the text. Focus group participants found this approach

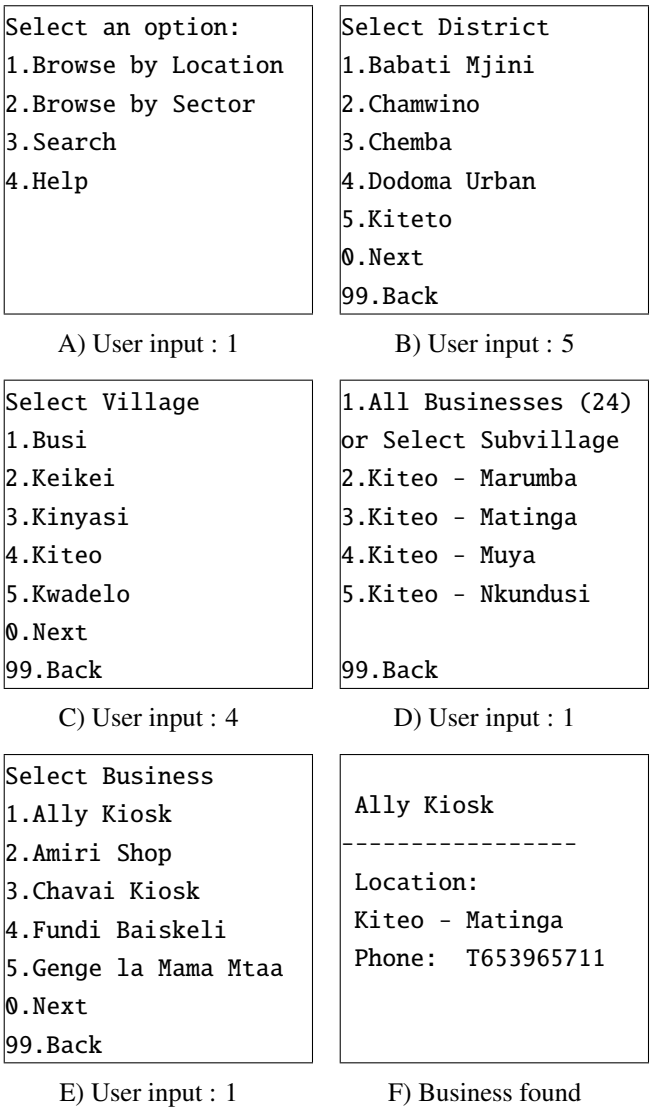

Figure 3. An example eKichabi session. Screens A-F show browse by location to find Ally Kiosk. Text translated to English for publication.

to be confusing; they reported being unsure of how best to use the search. Subsequent discussion of a variety of search functionality possibilities concluded with substantial enthusiasm for the search functionality described in the first part of this section; additional focus groups were very positive, and on this basis we settled on the final implementation, making minor tweaks to the wording of menus at the suggestion of participants.

METHODOLOGY

The study consisted of 3 phases: Phase 1 consisted of focus groups to discuss directory usage and try the prototype eKichabi, Phase 2 was an initial deployment of the application for one month with 107 participants, who were given access at no cost, and Phase 3: follow-up phone surveys of the initial users.

All research activities were conducted under research protocols approved by our university IRB. Our research was deemed to be exempt due to the minimal risk posed to subjects. Additional approvals were acquired from local authorities in keeping with the standard local procedures used for many prior projects in this setting. These included presentation of the research plan to the director of our partner institution (who has standing authority to approve local research projects), acquisition of permission letters from the district administrative secretary, and presentation of research permissions to village leaders before beginning any research activities. All participation was strictly voluntary, and participants were aware their usage was being monitored.

Study Timeline

We conducted field work from mid-July to mid-September 2017. Several of the authors traveled to the study area numerous times, with work based in the city of Dodoma, in the southeast corner of the study area. Focus groups were conducted first, in six villages. Feedback from participants was used to refine the eKichabi application. Hosting of the eKichabi was then moved to a higher capacity server in order to handle the increased use expected during Phase 2. In August, we enrolled participants into initial deployment, over the course of one week. Follow-up phone surveys were conducted with all participants in the initial deployment between September 7-12, and logging of eKichabi use was completed on September 15th.

Phase 1: Focus Groups

Focus groups were held to evaluate the *feasibility*, *usability*, and *acceptability* of the eKichabi. We visited 6 villages in the study area over a period of one week, with several focus groups held at each village, depending on the availability of participants. Focus groups had 3 to 12 participants and lasted approximately 1.5 hours each. These groups were led by researchers from the Institute of Rural Development and Planning in Dodoma, with the assistance of team members from a US university. Before traveling to a village, researchers contacted the Village Executive Officer (VEO) by phone, and requested permission to visit the village. The VEO then assisted the researchers with gathering participants. Effort was made to include participants with a range of ages, genders, and education levels.

Focus groups were conducted in two halves, with the first half discussing the information need addressed by the paper directory, and the second half evaluating the performance of the eKichabi directory prototype. We began the first half with introductions and the gathering of relevant demographic information (name, age, phone number, and number of mobile money transactions in the past month) for each participant. We then distributed copies of the paper directory. Many participants had previously used the paper directory, and many had their own copies which had been distributed as part of the earlier Kichabi project. We asked these participants to discuss their experiences with the paper directory – how frequently they had used it, whether they found it easy or difficult to use, and if they had stories to share about times that it was helpful or frustrating. All participants were asked to use the

paper directory to complete a series of tasks that were later compared with the digital eKichabi. These tasks included looking up a specific business in a distant village, looking up a local business that the participant already knew of, and finding any business that matches a given query - for example, "find a motorbike repair shop in Kondoa."

After these tasks were completed and debriefed, each participant was given a demo phone, an inexpensive Nokia candybar handset of the type most common in the area (see figure 2), and given instructions on how to dial in to the eKichabi application. Participants were given an explanation of the three different usage modes- Browse by Location, by Sector, and Search. Participants repeated the tasks described above, and were encouraged to explore the application on their own, making sure they tried all three usage modes. After the participants had been given time to do so, a group discussion was held. Participants described their experiences, and explained what aspects of the application, if any, were particularly difficult or easy to use. We then asked which of the three browsing modes they preferred, and why. Participants were given an opportunity to ask questions, thanked for their time, and the focus group was concluded.

Phase 2: eKichabi Deployment

After the focus groups were finished, a group of participants residing in the study area were given access to the eKichabi on their own personal phones, in order to gather information about how users interacted with the eKichabi application outside of the structured environment of a focus group. Participants were selected to be broadly, if not statistically, representative of the diverse range of ages, education levels, and income levels of the residents of the region. Four village in the area were selected: Azimio, Itiso, Pahi, and Soya. These villages were selected because they vary in population and remoteness. All have consistent cellular coverage on the Airtel Tanzania network, allowing us to provide the eKichabi at no cost to the users. Like all villages in the study area, these four have sufficient electrification to support the use of mobile phones.

Researchers visited each of the four villages on a separate day, arranging ahead of time with the VEO for assistance with gathering participants. Enrollment meetings were held with 10-30 people, and lasted 1.5-2 hours each. If there were more participants at a village than were able to fit into one meeting, or if participants wished to enroll but were busy at the time the meeting was held, then multiple meetings were held at various times throughout the day. We started meetings with a sign-in form, collecting some background information, including age, education level, type of phone and number, and mobile money usage. These phones were then whitelisted to access the eKichabi. A total of 107 participants were enrolled. Participants were given a paper handout with simple instructions about the eKichabi, the short-code to access it, and the number of a help line to call with questions. Surprisingly, no participant ever called the help phone.

Once participants had access to the eKichabi on their personal phones, the group worked through several sample tasks together, using each of the three usage modes to find the same business in turn. Participants helped one another with the application, and frequently asked questions of the researchers conducting the meeting. After the sample tasks, participants were given more time to experiment with the eKichabi, and to ask any more questions they had. Participants were then thanked for their time, and encouraged to continue using the eKichabi as part of their day to day activities.

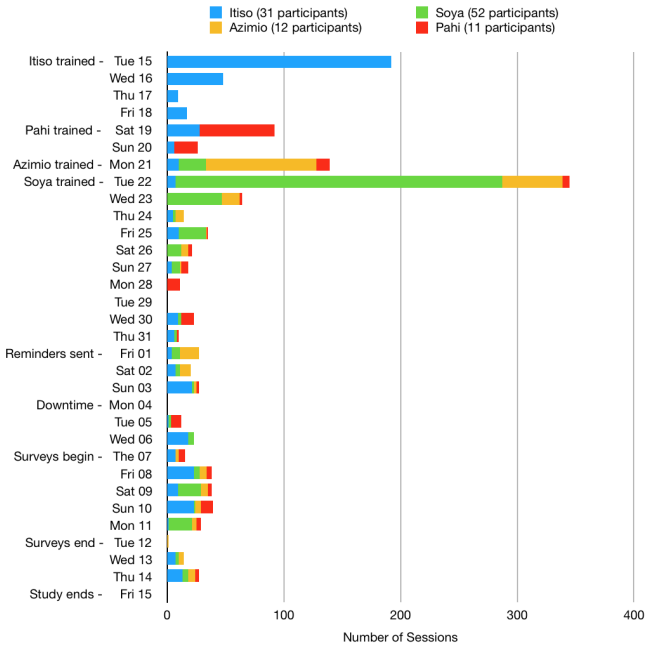

Figure 4. Day-to-day eKichabi usage. Enrollment days are clearly evident as large spikes, after which there was constant continued use.

Every session with the eKichabi was logged by the server, recording the screens displayed and input received, in addition to the date, time, and session user. After 2 weeks, on September 1, all users were sent an SMS reminder. The content (in Swahili) of the reminder varied — frequent users, those with more than 10 total sessions, were thanked for their usage, while less frequent users were asked to give the eKichabi another try.

Figure 4 displays the usage of the eKichabi over the course of the deployment. Enrollment visit days to villages are clearly evident, and it's clear that the effects of the reminder texts were negligible. September 4th has noticeably less usage than the other days – on this day, the cellular gateway used to connect to the application went down temporarily, rendering the application inaccessible for the day.

Phase 3: Follow-up Phone Surveys

The final phase of the study was a series of phone interviews conducted with participants in the initial deployment. Interviews were conducted in Swahili by researchers from September 7-12. The team attempted to reach all participants. Ultimately, surveys were completed by 65 participants — 61% of those who participated in the initial deployment. Phone interviews took approximately 15 minutes, and each participant was asked a series of scripted questions about their experience using the eKichabi. These questions focused on several topics:

1. Location of eKichabi usage – at home, while traveling, at work or elsewhere.
2. Shared usage – did the participants lend their phone to others, or look up businesses on the behalf of others?
3. Accessed business – were they located in the participant's village, or far away? Did the participant look up businesses they already knew about?
4. Usability – which features were easy to use, and which were frustrating?
5. Browsing mode preferences – which of the three usage modes did the participant prefer, and why?

Once the surveys had been completed by all reachable participants, the results were tabulated for analysis. The phone surveys were noted to increase the usage of the eKichabi, as is evident from Figure 4, as many participants mentioned during the survey that they hadn't used the eKichabi recently, and that they intended to try it again.

RESULTS

Phase 1: Focus Groups

The focus groups offered an opportunity for in-person feedback from users on what features they found easy to use, what they found difficult or confusing, and what options they preferred. With some training, almost all users were successfully able to locate businesses in the eKichabi, and a great number expressed enthusiasm for the service, asking if they could use it on their own phones. Participants who reported using other USSD applications (most commonly mobile money) the most frequently tended to learn how to use the eKichabi the quickest, and with the least instruction. Conversely, older users and users who didn't own phones required the most assistance.

All focus group participants tried using both the search and the browse modes of the application, and most users expressed a distinct preference for one over the other. However, users varied greatly in which of the two they preferred. On the whole, both the power users (users who quickly learned the application and were comfortable with all usage modes) and the users who struggled the most said they preferred search, albeit for different reasons. Power users said they preferred search because it provided the fastest (fewest screens) path to the desired business, whereas users who struggled preferred it because they found selecting items from the menu to be confusing. Interestingly, users in the middle of the spectrum preferred browse, because *"it was easier to select options from a list,"* as one participant stated.

A number of common difficulties with eKichabi were also uncovered during the focus groups. Mobile Network Operator-enforced time-outs frequently frustrated novice users, who would often take their time reading all the text on a screen before making a selection. Almost all users, upon making an error or being presented with an unexpected result, would simply end their session and resume from the beginning, despite the availability of the "go back" option. When asked, one participant explained that this was because other USSD applications do not offer the option to go back, and as such, he was in the habit of immediately ending a session after making a mistake. Scrolling also posed a challenge, especially for users who were less comfortable with the application. In addition to the requirement to select "0. Next" on long menus, as described above, screens filled many lines, requiring the user to use the 4-way controller on the phone to scroll through a single screen. Many novice users struggled to remember to scroll through the whole screen, and as such would miss text at the bottom of a menu.

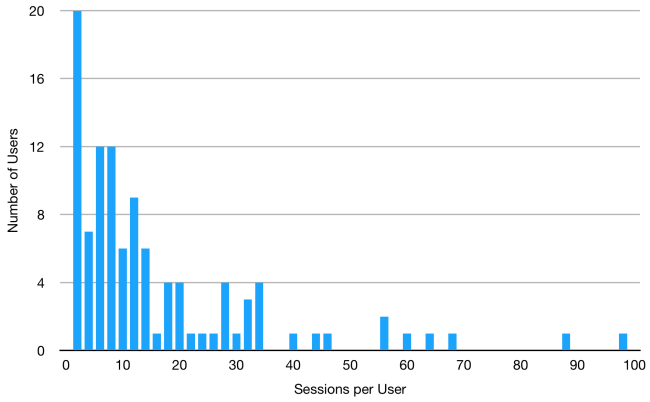

Figure 5. Histogram of the number of sessions per participant excluding training sessions over the 30 day study period. 75% of users had more than five sessions.

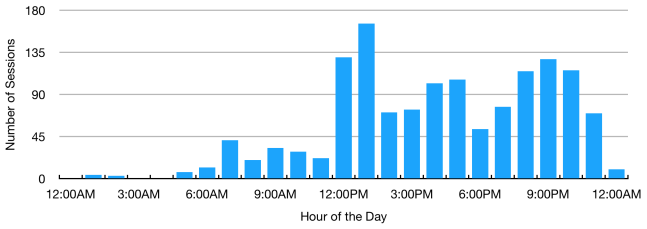

Figure 6. Histogram of eKichabi use by time of day, excluding training sessions. Majority of use was in afternoon and late evening.

Phase 2: Initial Deployment Log Analysis

Usage of the eKichabi exceeded expectations. While Figure 5 indicates that many participants did not use the application more than a handful of times, the bulk of the users accessed the eKichabi more frequently. 25% of users were 'Infrequent,' with less than 5 sessions over the duration of the study period, averaging slightly more than one use a week — even this level of usage represents a substantial expression of interest in using the eKichabi to locate new contacts. 53% of users 'Frequent' accessing the eKichabi every few days, with between 5 and 25 sessions total, inclusive. 22% of users were 'Daily' users, accessing the eKichabi more than 25 times over the course of the study.

Figure 6 shows the distribution of eKichabi usage by time of day. Participants access the application most around midday and in the late evening. There is also substantial activity in mid- to late-afternoon. Low usage in the morning is consistent with the working habits of farmers in these communities, who

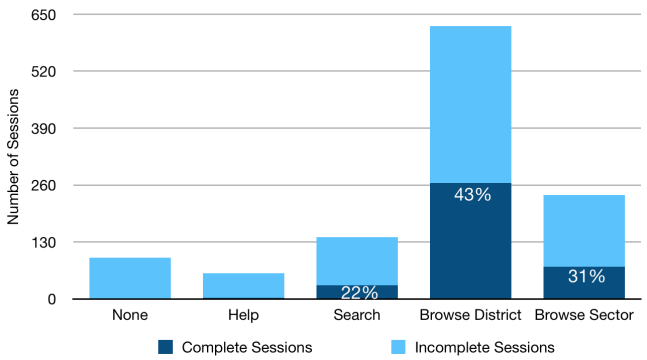

Figure 7. The number of complete and incomplete sessions per browsing mode, with the percentages of complete sessions for each included.

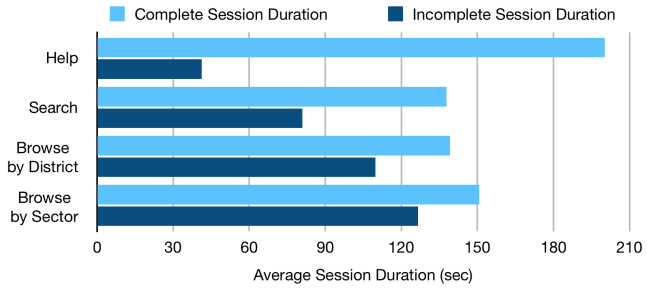

Figure 8. Average duration of both complete and incomplete sessions for the different usage modes.

tend to visit their fields first thing in the morning and stay for 4-6 hours.

Usage Mode Analysis

Figure 7 shows the distribution of usage modes. One can see that the two menu-based 'Browse' modes together account for three-quarters of all sessions. These two modes, plus the 'Search' mode, constitute the bulk of the application, as they are the only three usage modes that allow a user to find businesses. The rest of the analysis focuses primarily on these three usage modes.

A key focus was participants' preferences between searching by entering text, and browsing by selecting items from a menu. Little is known about the information-search preferences of users who lack access to the Internet or to paper-based directory systems, yet the majority of future growth in usage of mobile applications will come from this population. For this analysis, we defined 'complete' sessions as any session that ended at the details screen of a business, and any session that ended without reaching a business as 'incomplete'. An incomplete sessions may still be useful, for example, if it shows the user that a particular type of business does not exist in a specific village. Likewise, a complete session may end on an entry that is ultimately not useful for the user, requiring him or her to initiate another eKichabi session. It would be incorrect to confuse 'completed' sessions with *successful* or *useful* sessions, which are less easily identified from log analysis. With this caveat in mind, we use the above definition of complete sessions to calculate the completion rate for each of the different browsing modes. Figure 7 shows these completion rates. Browse by District had the highest completion rate, followed by Browse by Sector, Search, and finally, Help. We suspect that, to some degree, the lower completion rate for Search is explained by its steeper learning curve (as seen in focus group trials) — many participants unsuccessfully tried the search a few times, and then mostly gave up on it, whereas some participants found it to be easier to use than the Browse modes. Help sessions have a dramatically lower completion rate because most users viewed the help, then ended their session and started a new one to look up a business.

We also looked at the average duration of both complete and incomplete session by usage mode, in Figure 8. As can be seen, regardless of usage mode, complete sessions tended to be longer than incomplete sessions, as is expected. Both Search sessions and Browse by District Sessions were faster than Browse by Sector sessions. The large discrepancy between the average duration of complete versus incomplete Help sessions is explained by the fact that to reach a business from the Help screen, one must go back to the main menu and then select another usage mode - most users simply ended their session at the help screen, and began another one.

Session Clusters

Continuing with the analysis of the timing of sessions, we recognized (and witnessed in focus groups) that frequently a user would use several sessions to look up a single business. Sometimes a user made an error and started over, sometimes the user's session would time out, or other times, the user would try multiple different usage modes before selecting a business. Multiple sessions could also indicate attempts to find several businesses, or to check for the same type of business in different locations. We defined a 'session cluster' as a group of sessions by a single user that occur within 10 minutes of at least one other session in the cluster. Based on the data, a threshold of 10 minutes seemed a natural choice, as there was little change in the number of clusters if this threshold was increased.

Clusters have a far higher completion rate than individual sessions. While individual sessions had an average completion rate of 30.8%, 54% of clusters contained at least one complete session. Furthermore, the greater the number of sessions in a cluster (the size of a cluster), the more likely it was to contain at least one complete session. Clusters of size 1 (i.e., sessions that were separated from preceding and following sessions by at least 10 minutes) were complete only 31.6% of the time, but clusters of 4 sessions were complete more than 75% of the time. All clusters containing more than 10 sessions were complete. This type of behavior indicates a 'trial-and-error' approach to engagement with the eKichabi, as users come to know both what information the service makes available, and how they might best navigate and access it.

The sizes of clusters varied dramatically – while the average cluster (including clusters of size 1) contained 2.78 sessions (lasting 6 minutes 29 seconds), many were larger and longer

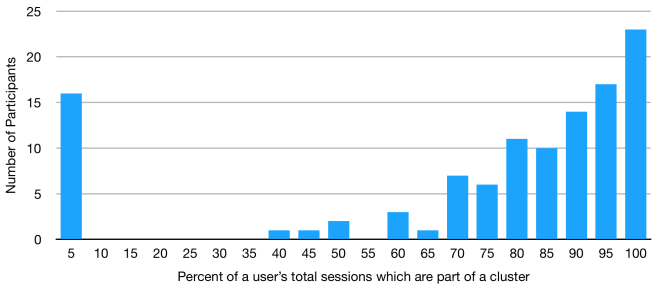

Figure 9. A histogram of the percentage of users' sessions which were contained within a cluster of 2 more sessions.

– one user had a cluster of 36 sessions, collectively lasting longer than an hour!

Some users also had dramatically more of their sessions occur within clusters of multiple sessions than others. As Figure 9 shows, this distribution is surprisingly bimodal — some users used the eKichabi exclusively with single sessions separated by more than 10 minutes, whereas many others had the vast majority of their sessions contained within clusters.

Phase 3: Phone Surveys

The results of the phone surveys both confirmed, and in some cases supplemented, our findings from Phases 1 and 2. Of greatest interest were the data regarding where participants used the eKichabi, and who (if anyone) they shared it with, as these are topics that could only be addressed speculatively in focus groups.

Many participants expressed a great deal of enthusiasm for the eKichabi because it would enable them to look up businesses on their phone while away from home, and many owners of paper Kichabi books (from previous studies) reported leaving theirs at home, then being unable to look up a business when the need arose. Despite this, the majority of eKichabi use seemed to happen at home – 64.6% of participants reported using it there, compared with only 10.8% at work, and 4.6% while traveling, and the most prolific users were no more likely to report using the eKichabi away from home than the least prolific. To some degree, this can be explained by the relatively short duration of the study period, and its occurrence during a time of year when people are less likely to travel for business purposes.

The participants that did report using the eKichabi while traveling often explained how it was useful for finding transport when in a less familiar area. One man described, *"I used [the eKichabi] to find a boda boda* (a motorbike taxi) *when I was in Solowu, and I got the transport back to Itiso."*

Participants also mostly kept the eKichabi to themselves, with only 6.1% of participants reporting that they used it to look up businesses for others. The participants that did so mostly did so for friends: One participant explained that *"a friend wanted to travel to Kondoa to buy onions, [so I] got him some numbers, and he made a deal before traveling."* The eKichabi did attract interest from those who didn't have access – 15.4% reported that they shared their phone with curious family members so that they could try.

While many participants reported calling businesses they found in the eKichabi, most of them called those numbers by dialing them directly, as only 10.8% reported saving any businesses to their phone's contacts.

The survey also asked about which of the three usage modes they preferred to use. Many participants did not give definitive answers, saying that they either had not used the application enough to form an opinion, or liked all of the options equally. Encouragingly, of the participants that did state a clear preference, the distribution matched remarkably closely to the observed rates of use extracted from the logs. The reasoning for participants' preferences were mostly consistent with what was found in the focus groups. Participants who preferred search liked its simplicity and speed. *"Tafuta* (Search) *is the best, because you don't have to choose from so many options."* one explained. Another woman said she liked it *"because it's short and simple to get to the business you are searching for."*

Participants who preferred one of the browse modes, on the other hand, liked selecting from a list of options. One man said *"The most preferred is Chagua Mahali* (Browse by Location) *and Chagua Sector* (Browse by Sector), *because they have so many options to look up that allow any person to choose different villages and sub villages."*

When asked for additional comments, participants had many thoughts, ranging from requests for us to enroll their friends, to more outlandish suggestions for features to add. One man asked for us to include a registry of motorbike license plates, *"so it could be easier for us to find if someone steal the boda boda."* Some common threads emerged in these comments: Participants' most common requests were for additional sectors of businesses to be added to database, or for the area covered to be expanded to include more of the country.

DISCUSSION

Feasibility

The initial deployment of the eKichabi demonstrated that USSD is a feasible technology upon which a directory application with thousands of entries can be built. Such applications are compatible with all mobile phones in use in rural, undeveloped areas, and can be used as long as there is cellular coverage. Implementation technologies are straightforward, and the solution can be hosted and deployed with existing services. Over the course of our month-long deployment, the eKichabi application hosted nearly 2,000 sessions with 10,000+ screen views, and provided contact information for 500+ businesses, with 97% uptime. USSD session time-outs did not seem to be a major barrier to usage, as we observed sessions with durations of up to 10 minutes. This finding of feasibility is significant in and of itself, as to our knowledge, no third-party USSD application for on-demand information dissemination has been deployed on this scale before.

Usability

Based on observations of use in focus groups, responses to follow up interviews, and most importantly, sustained use,

we consider the application to be usable. The basic usability problems of a USSD application for information access including navigating hierarchies, filtering with multiple criteria, and scrolling through long lists were all handled adequately, resulting in an application that allows a user to access contact information for thousands of businesses. While there were occasional frustrations, the vast majority of participants were able to access businesses consistently, with only a handful of individuals struggling to use the application. There were difficulties for individuals who had very poor eyesight and could not read the screen of the phone, and individuals who had never used a mobile phone before. We also saw evidence of users picking up the application without any training.

However, there are opportunities for improvements. The most frequent challenges reported by users in the focus groups and phone interviews were confusions about menus with large numbers of items, and the lack of discoverability of the 'back' option: many users simply started their session over after making an erroneous input. Future work on these areas, such as the implementation of an option to restore a user's previous session without their last input, will help alleviate some of these challenges, and logs of users browsing can help inform improvements.

Acceptability

The eKichabi fulfilled an unmet need for business information to participants in the study, as evidenced by the both the anecdotes we heard during focus groups and phone surveys, and the number of participants who asked excitedly to join the initial deployment, or requested the expansion of its coverage area. Participants found the eKichabi to be useful in range of situations, exemplified by quotes from users:

- Transport to or from unfamiliar locations: *"I looked up the business in Itiso and called a boda boda guy to seek the transport."*
- Price comparisons for buying or selling items: *"I am a crop trader, and I called merchants in Dodoma to inquire about prices for my crops. I called several businesses to find who would give me the best prices."*
- Negotiation of deals without needing to travel: *"I called a seed vendor in Kondoa, and negotiated over the phone, then he drove the seeds [to my village]."*

Users also commented on their preferences for the electronic format of the eKichabi, with many focus group participants explaining that the application was especially useful since they always have their phones with them. This portability is especially important for the spur-of-the-moment type queries (such as the transport requests, above).

Search

While more participants used the menu-based 'browse' features of the eKichabi, many participants told us they preferred the search option. This result was surprising to some of the authors, including one with substantial field experience in the study area, who had expected that menu traversal would be used exclusively. Participants tended to formulate their search vs. browse preferences based upon opposing reasons: Participants who preferred search explained that they liked how they could avoid having to navigate through many layers of menus with numerous items, whereas those who preferred using the menus said they liked how they could see all their options, and be guided (via a series of menus) directly to the business they were looking for. The fact that search appears to be a viable option for some users of a USSD application opens up a significant design space.

Cost

In our deployment, the eKichabi was provided to participants at no cost, with hosting and gateway fees funded by research grants. The eKichabi offered value to its users, we made no attempt to measure their willingness-to-pay for access to the directory – this is an area for future work. Furthermore, as it has been observed that as soon as an ICTD project starts to charge for services, usage drops to near zero [31], a model of charging per use may not be viable. More work is needed in developing the business model, and we note that there are several business models that could make USSD queries free on a basic model phone including charging for listings, developing a smartphone app with a premium service, adding advertising, or making the eKichabi a public good [10].

Scalability

The scalability of the eKichabi is an important consideration, and an area for future work. There are no significant technological challenges on the server-side to adding many thousands of businesses; the challenge is how to do so while maintaining usability on the user's side. By adding additional level of locational hierarchy (region, country, continent, etc) it's possible to support an arbitrarily large area containing many businesses, and we have demonstrated the feasibility of this for an area of 5000 square miles, containing more than 200,000 people. To save the user from needing to navigate through several layers of menus at the beginning of each session, one possible feature for future implementation is a 'default location' that the user could enter once; subsequent sessions would all start at this location, be it a specific district, village or subvillage.

CONCLUSION

The initial deployment of the eKichabi demonstrated the feasibility, usability, and acceptability of a third-party USSD application for on-demand information access. The use of USSD for applications such as the eKichabi is well suited to people living in rural, developing areas, as USSD functions on all mobile phones, and can be deployed inexpensively.

The eKichabi project also demonstrates the successful conversion of a paper phone book into an electronic application, which is the only feasible method of scaling such a directory to include more businesses, cover a larger geographical area, and reach a greater number of users.

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