Robustness of the mHealthSurvey Midlet for Real-Time Biosurveillance

Nuwan Waidyanatha
LIRNEasia
12 Balcombe Place, Colombo 08, Sri Lanka
email- nuwan@lirneasia.net

Kannan T., Sheebha R. and Vincy A.
Rural Technology and Business Incubator
Indian Institute of Technology – Madras
Guindy, Chennai, India
{tkannan, rsheebhar, vincy @tenet.res.in}

Abstract - **m-Health applications, limited by the miniaturization aspects of the mobile hand held devices, cannot provide the extent of functionality that laptops or desktop-computers can. However, the omnipresence wireless networks, mobility of the hand held communication devises, pervasiveness, adaptability, and cost effectiveness, of mobile hand applications, allows for digitizing health information in the rural settings of Sri Lanka and India. The Real-Time Biosurveillance Program developed "mHealthSurvey" mobile application serves this purpose of collecting clinical data for executing spatial and temporal statistical analysis to detect adverse events. This paper discusses the effectiveness of the mHealthSurvey for digitizing health records for receiving reliable and timely health records.**

I. INTRODUCTION

Problem faced by the Health Officials in India and Sri Lanka is receiving health information in a timely manner in order to prevent diseases reaching epidemic states. The present day disease notification paper system does not provide the "real-time" information flow for rapid detection of outbreaks. The real-time communication shortcomings can be easily overcome with reliable and robust Information Communication Technologies (ICTs) [1], [2], and [3].

The Real-Time Biosurveillance Program (RTBP) is a pilot project, taking place in India and Sri Lanka, aiming to answer the question *whether software programs that detect events in health symbolic and categorical data sets and mobile phones that collect health data and receive health alerts are able to predict and prevent disease outbreaks in near-real-time*.

There are other initiatives of similar nature – use of mobile phones (or m-Health programs) for disease surveillance. Three such applications are the Cell-Life, Episurveryor [4] and e-MICI [5] developed for monitoring epidemiological information. However, those applications are geared for collecting data on specific known diseases, namely HIV/AIDS, Tuberculosis, Malaria, Child illnesses, etc. Moreover they run on high end mobile phones or PDAs. The difference that the RTBP developed mHealthSurvey, besides working on cheap Java and General Packet Radio Services (GPRS) mobile phones, is that it surveys high volumes of all patient cases (disease and syndrome) in accordance with the World Health Organization's policy that disease surveillance systems monitor all diseases [6].

II. APPLICATION DEISGN

A. Midlet Architecture

The mHealthSurvey [7] software application is a Java 2 Micro Edition (J2ME) Midlet built on MIDP2.0 (Mobile Information Device Profile) and CLDC1.1 (Connected Limited Device Configuration) JSR (Java Specification Request) components. This allows the Midlet to be ported on to any, manufacturer independent, mobile phone that supports the same (MIDP2.0 and CLDC1.1) or higher versions of the JSR that transparently interact with the mobile device display/controls and connectivity, respectively [8]. In order to ensure that the mHealthSurvey could be ported on to any MIDP2.0 and CLDC1.1 compliant mobile phone, the Midlet was successfully tested on a Nokia 3110c, Amoi A636, Gionee v6600, Gionee v6900, Motorola SLVR L7, Sony Ericsson s302c.

Midlet uses GPRS to transport data between the mobile phone and the server but does not require a dedicated connection to function (i.e. can work off-line). Besides the bulk download during the initial setup, each transmitted health record takes less than 2Kb. Data is communicated through Hyper Text Transfer Protocol (HTTP) Post, Request, and Get functions that follows a REST (Representation State Transfer) like architecture [9].

Users download and install the 22Kb Java Archive (JAR) file through the mobile phone's Wireless Application Protocol (WAP) browser. Although the application is generic and can be widely adopted for collecting syndrome information, the implementation specific attribute labels in the Graphic User Interface (GUI) and the Uniform Resource Locater (URL) that points to the WAP site, connecting to the database, must be custom altered before building the JAR file. This is to reduces the human computer interaction ambiguities.

B. Software Functionality

The main menu of the mHealthSurvey comprises: download list, profile, location, off-line survey, and health survey (Figure 1 (a)). First step is executing the *download list* function which retrieves the lookup values from the server such as the list of disease, sign, symptoms, age-groups, gender names, case-status, location types, and health worker types, into the mobile phone's Record Management System (RMS). This is usually a onetime step but users are encouraged to execute this function periodically to update the list of disease, signs, and symptoms that continuously grows. Secondly, they registered their profile in the mHealthSurvey, which in turn shares this information with the database. This process, equivalent to a login function, is in place to authenticate the user as well as to associate the records for accountability. A single installation allows for registering multiple profiles for sharing a single mobile phone. Thirdly, the users download the set of villages specific to their working jurisdiction by entering the name of the health sector specific jurisdiction and submitting the parameterized request to the server. Following the successful completion of the three step configuration, users may begin submitting data.

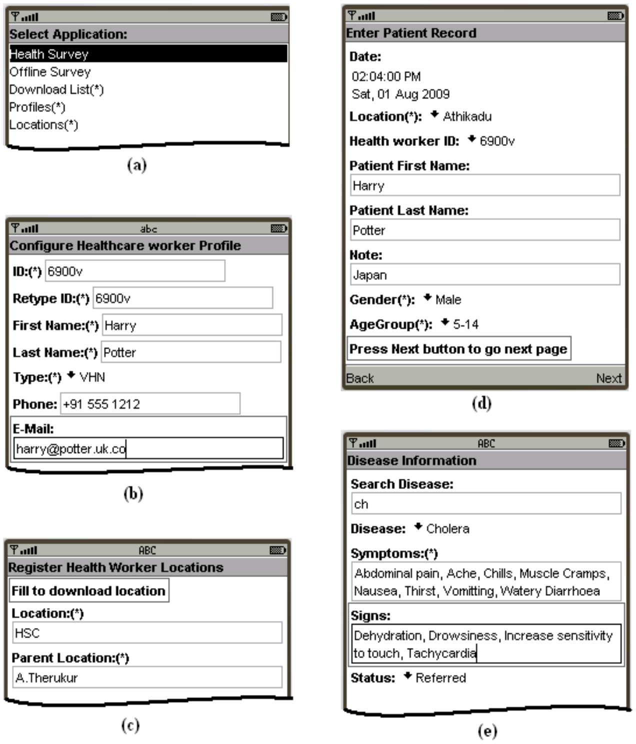

Figure 1: Graphic User Interfaces of the mHealthSurvey

Attributes of the *health survey* (health record submission form) are – case date time, profile id, location name, patient first name, patient last name, notes, gender, age-group, disease, symptoms, signs, and case-status (Figure 1(d) and 1(e)). Location, symptoms, age-group, and gender are the mandatory fields a consequent of the outbreak detection analysis requirement. Anticipating that the health workers are submit real-time data, the date and time, by default, is set to the current date and time but can be changed. Profile Id, location name, age-group, gender, and status are pre-populated drop down lists that are initially set through the download list, profile registration, and location defining functions. For the sake of the implementation in India, patient's name is included, which is optional.

If the patient is diagnosed, in screen two (Figure 1(e)) of the health survey, the user can type the initial few characters of the disease name in the search disease text box. It will then display the predicted diseases. Once the appropriate disease is selected, the list of associated symptoms and signs automatically populate in the respective text boxes but can be edited to reflect the true nature of the patient complaint. Undiagnosed patients are labeled with "unknown" but, at minimum, the patient complaint (symptoms) must be typed. In the event a disease is not in the mobile phone RMS, the user selects "other" as disease name then enters the new disease name. When the server receives the record and validates the disease to be absent in the database, it will include that new value in to the database's disease list. Thus, allowing the database to evolve. Same database evolution rule applies to unlisted symptoms and signs.

III. RESEARCH DESIGN

A set of Health Workers, 29 in India and 16 in Sri Lanka, were given training and a mobile phone to submit data. Data in India comes from four Primary Health Centers and twenty five Health Sub Centers. In Sri Lanka data is collected from a total of twelve hospitals and clinics by the trained data-entry-operators. The data submitted is identical to those handwritten by Medical Officers or other Health Workers in Outpatient Registries or Treatment Chits. The health workers in India are those working in the health institutions; while in Sri Lanka, a set of volunteers were introduced to the health institutions. The Indian case mimics the adoption of the mHealthSurvey by existing resources; while the Sri Lankan case mimics the inception of a new resources persons to the institution.

IV. METHODOLOGY

The success of the introduced ICT depends not only on the quality of the technology artifacts but also on the actors [10]. Hence, one of the main components that the research will evaluate is the workability of the technology in the given environments. The capacity to use and adopt the application was objectively measured through data submission rates; specifically, real-time data submission and quality of the data [6] and [11]. Qualitative aspects were measured through face-to-face interview [3] and [12]. A staged usability exercise was conducted with the users to determine their ability install and configure the application, efficiency in data entry and submission, and knowledge on standard operating procedures.

V. RESULTS

Table 1: Task completion mean times in minutes with standard deviation in parentheses ()

Task	Maximum	India	Sri Lanka
Download, Install JAR and Configure Midlet	12.00	17.48 (12.05)	11.42 (3.99)
Submit 6 health records	20.00	27.26 (14.00)	12.50 (3.72)

Frequent health record submission in India and Sri Lanka began in June 2009 and September 2009, respectively. We show four stacked area plots, Figure 2-5, for the two countries on two themes: real-time vs off-time data submission and clear (good) vs noisy (bad) data submission rates. Real-time data are those that are submitted during peak patient visitation times (i.e. 8am – 1pm); while other-time data are sent during another time. Corrupt data by definition are those data with misspelling of disease, symptom, or signs when using "other" as an option, described in section II(B). To establish a common basis for comparison W01 – W13 (Week 1 through 13) are relative to the actual data submission start dates in the two countries.

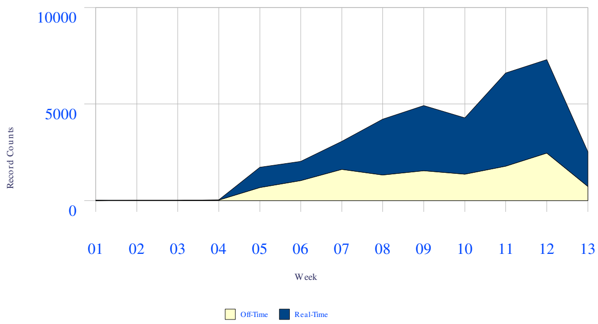

Figure 2: Plot of Real-Time and Off-Time counts in Sri Lanka

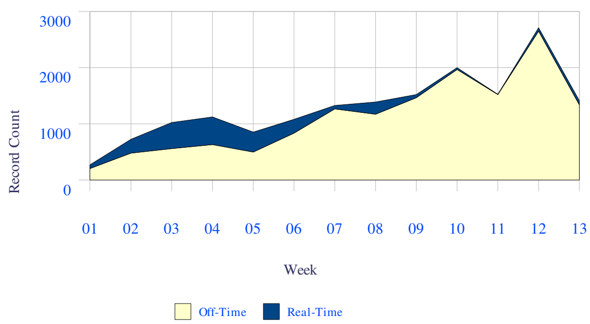

Figure 3: Plot of Real-Time and Off-Time counts in India

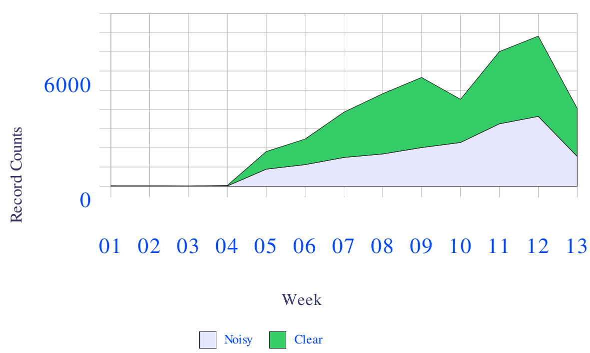

Figure 4: Plot clear and noisy record counts in Sri Lanka

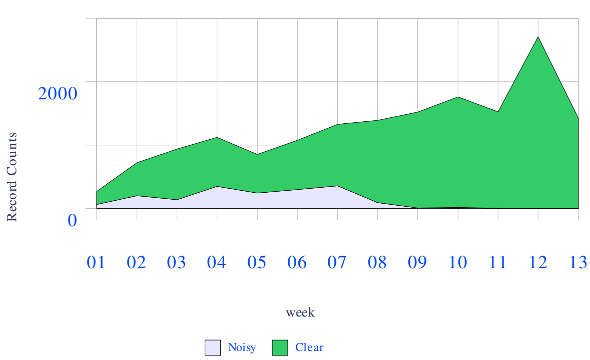

Figure 5: Plot of clear and noisy record count in India

VI. DISCUSSION

Some of the health workers who had not used a mobile phone beyond voice, prior to the project introducing the mHealthSurvey, with a one day training session, were able to adapt to the newly introduced technology. However, Table 1 shows the Indian health workers to have exceeded the expected time to complete the JAR download, installation, and Midlet configuration process. Also the average completion time of submitting 6 records is higher than the maximum expected time with various levels of competency. On the other hand the Sri Lankan health workers performed their tasks in time and show a more uniform competency. The health workers in India are between the age of 35-55 with only prior experience with mobile phone voice; where as the Sri Lankan health workers were much younger generation (ages 18 – 35) with prior experience with SMS and not just voice communications [13].

Finding time to complete the records without disrupting current work flow may be a significant barrier to adoption of the technology for real-time data submission, as several health workers mentioned this during face-to-face interviews. 50 percent of the health workers in India chose to enter the data at the end of the day; while others entered data every 2 – 3 days or on the weekends. Some of the data-entry-operators, in Sri Lanka, were asked by the hospital's chief medical officer to come in the afternoons, avoiding the morning chaotic hours, to receive the medical paper chits to extract and submit the data. This notion is also evident from Figures 2 and Figure 3 that show 14 and 66 percent of the data to arrive in real-time in India and Sri Lanka respectively.

In several locations it was apparent that some health workers in India have not entered many (if any) records into the system so far. Following, the periodic intervention of trainers, on a one-on-one basis, has shown signs of improvement in the data entry. In the case of Sri Lanka the health workers had difficulty reading the medical officers' handwriting before digitizing and in several cases the medical officers were forgetting to write the diagnosis in the medical paper chits. Writing the diagnosis on the chits was a project introduced requirement. The learning curve is slow and progressive but has not achieved the anticipated magnitudes.

After talking with health officials and medical officers, the project came to know that over 100 patients visit the hospital and clinic each day in Sri Lanka and the same amount in the Public Health Center in India. The Health Sub Centers may see only 50 patients a week. Given these numbers, the project anticipates, at least, 4000 and 7200 records to arrive from India and Sri Lanka, respectively, each week. Figures 2 and 4 show that the introduced resources persons are meeting the expected target counts. However, the counts are still falling short in India. When inquired the project revealed that the Indian health workers were overwhelmed with their workload. They are doing double entry, first recording the case details on paper then later digitizing those records during off-time. It is possible that they are forgetting to pencil some of the cases, which results in loss of records.

During the first 8 weeks the Indian health workers were negligent and had 23 percent noisy data. However, after making them aware as to how that would affect on the statistics they corrected themselves and now have subdued the noisy data. On the contrary the Sri Lankan health workers, despite several awareness actions, continue to send noisy data, which accumulates to 43 percent of the total. This is mainly a repercussion of the lack of a comprehensive database of disease symptoms and signs, where the data-entry-operators are forced to digitize the unreadable hand writing of the medical doctors and were unable to decipher the spelling of the medical terms.

The health workers in India see value in the system and have an incentive to ensure the reliability of the data; whereas the Sri Lankan health workers who are newly introduced for the purpose of collecting data for the project do not see any incentive in self-correction.

VII. CONCLUSION

Evidence to date show that the mHealthSurvey midlet is a worthy advocate for front line health case record digitization for the purpose of real-time biosurveillance. However, the application needs to be more robust in terms of applying means such as predictive text in the symptom and signs text boxes with a more comprehensive and complete set of disease syndrome relational database to minimize the erroneous data. Efficiencies of real-time data entry can be achieved by adopting slightly advanced mobile hand held devices with touch screen keypad with policies forcing the medical officers to enter the data at the point of care.

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