2014 IEEE 15th International Conference on Mobile Data Management

eHealth TABLET: A Developing Country Perspective in Managing the Development and Deployment of a Mobile - Cloud Electronic Medical Record for Local Government Units

Ma. Regina Estuar
School of Science and Engineering
Ateneo de Manila University
Philippines
restuar@ateneo.edu

Dennis Batangan
Institute of Philippine Culture
Philippines
dennis.batangan@gmail.com

Andrei Coronel
School of Science and Engineering
Ateneo de Manila University
Philippines
acoronel@ateneo.edu

Francisco Enrique Vicente Castro
School of Science and Engineering
Ateneo de Manila University
Philippines
fgcastro@ateneo.edu

Anna Christine Amarra
Ateneo Java Wireless Competency Center
Ateneo de Manila University
Philippines
camarra@ateneo.edu

Rose Ann Camille Caliso
Institute of Philippine Culture
Ateneo de Manila University
Philippines
rcaliso@ateneo.edu

John Paul Vergara
School of Science and Engineering
Ateneo de Manila University
Philippines
jpvergara@ateneo.edu

***Abstract*—In January 2013, the eHealth TABLET (Technology Assisted Boards for Local government unit Efficiency and Transparency) project began with a two-fold objective of: 1) creating a tablet based system that will integrate existing health information systems to address the national objective of a unified health information management system by 2015 and 2) to create a transparency layer at the local government units such that communication lines between municipal health officers and the mayor are monitored. Bottom up approach was used to ensure that all features requested by multi-stakeholders are included in the design of the system. The end product was a mobile - web based system with the mobile application having three main components: the electronic medical record (EMR) application which comprises of the patient record and diagnosis module, the requests/approval application, and the dashboard application for data visualization. Responding to the needs of intended users, the web based application provides the following features: web auxiallry entry, aggregated disease report application and usage monitoring . Regular usage monitoring increased usage over time. For ICT development projects in public health, iteratve involvement of multi-stakeholders is necessary to ensure higher acceptance and adoption. From a design perspective, technologies should be designed to be interoperable such that interfacing with existing systems will be seamless.**

I. Introduction

The national eHealth Framework of the Philippine government calls for the interfacing of several existing systems and databases in order to achieve its goal of unification. As of this writing, there are over 50 information systems related to health with around 5 systems directly being used by local government units in their health centers and barangays. However, the problem is that data redundancy exists because existing systems, having the same patients, do not speak with one another. With this premise, we began exploring the possibility of creating a tablet based system which will interface with existing systems such that there is only one data entry point. To address the issue of efficiency, the proposed system was designed to use web and cloud services so that real time health data can be accessed anytime and anywhere. In January 2013, the eHealth Technology Assisted Boards for Local Government Unit and Transparency (eHealth TABLET) project began with the objective of designing and implementing a tablet based electronic medical record system for municipal health officers as well as a transparency communication module between the Mayor and the health officer. After one year, eTABLET has been deployed in 10 municipalities nationwide with over 7000 health records after a 6 month deployment timeframe. This paper discusses management in three perspectives: design, development and deployment of a mobile - web application within the context of developing countries where low cost but high adoption and acceptance solutions are relevant.

II. Related Literature

Public health delivery has been evidently improved with the employment of Information and Communications Technology (ICT) in the systems and processes of the health sector [1]. Through ICT-enabled health sector services, geographic and financial barriers of delivering health-related needs to the public are minimized. This is especially true for developing countries where healthcare systems face inefficiencies and relatively high transaction costs [2]. In particular, the implementation of

978-1-4799-5705-7/14 $31.00 © 2014 IEEE
DOI 10.1109/MDM.2014.44

health information systems which ultimately aims to enhance the efficiency and safety of health care delivery services can contribute greatly to the decision-making processes of health managers across various geographic locations [7], [9]. Despite the perceived great benefits of adopting health information systems to facilitate transactions in the health sector, issues concerning the dynamics and processes of effectively managing and deploying these systems inevitably arise. Despite the high demand for various information systems, knowledge on effective deployment of an HIS that can meet the needs of its targeted end users is still insufficient [8]. Understanding the intricacies of deployment which includes how to customize the system, how to maintain the target populations utilization of the system, and how to innovate persistently so as to further enhance the functionalities of the system and more so, of the user experience, was suggested to be considered equally with the engineering the information systems [5]. Specific to HIS, a five-step approach software engineering approach is recommended [6]. Several studies show that the success of HISs rests not only on how sophisticated the design and development of the technology itself is, but also on how the technology was deployed and implemented both at the individual and organizational levels. It was proposed that at the very least, the implementation planning must include management involvement, integration in healthcare workflow and user participation, education and training, and establishing congruency between the software and the hardware [9]. The success of an HIS, as argued by Gladwin, Dixon and Wilson (in Premji et al 2012), largely depends on how well the system is received by its identified end users and how supportive the organizational structures and cultures are where the HIS was deployed [8]. Amongst the highly regarded approaches in developing and implementing an HIS especially in a developing country context is the use of bottom up approach. A study conducted by Byrne and Sahay showed that designing and developing a community-based child health information system in a developing country setting would require reconceptualization of the traditional participatory design [3]. They recommended taking a more inclusive approach in the development process which involves building the capacity of all the stakeholders, both the direct and indirect users [3]. In another study by Premji et al on the implementation of Community Health Information Tracking System (CHITS) in selected health centres in the Philippines, it was concluded by the researchers that implementers must recognize and be able to deal with systemic change management processes when deploying and assessing their HIS [8]). Implementation of a health information system like CHITS deployed in a multi-stakeholder environment must take into consideration not only the direct users but even those outside the health centres milieu. In the same manner, the initial deployment of the eHealth TABLET used a bottom up approach where several iterations of design frameworks evolved after every deployment [4].

III. Development Framework of eHealth TABLET

A. *eHealth TABLET application*

The eTABLET System is a client-server system developed on a Android mobile platform. The back-end service is implemented on a cloud environment, delivering communication responses to the Android front-end anywhere connectivity is sufficient. The current implementation of the cloud service is via Amazon Web Services, configured into a multi-instance setting where ten instances within one account represent the different virtual servers for each municipality the eTABLET is assigned to.

The Android front-end consists of four (4) subsystems. These are the Patient Record System, Graphs and Reports, Doctor Requests, and Mayor instructions. The Patient Record System is the point of data entry into the system. The Graphs and Reports provide a facility to visualize data in the form of maps, bar graph, line graph, pie chart thus providing the user with useful and required information regarding the health status of their municipality based on the data stored in the municipalitys exclusive cloud-instance. The last two subsystems (Doctor Requests and Mayor Instructions) provide the communication and documentation facet of the eTABLET application, allowing for increased transparency with regards to health related activities in the municipality that involve the communication between MHO and the Mayor.

The database implemented on the Amazon cloud was developed with Ruby-On-Rails. The configuration allows for data to be stored in the exclusive cloud-instance of each municipality. This environment does not allow data access across instances, thereby preventing any municipality to view patient data from other municipalities. This approach provides a security layer in data access. A mother-instance in the cloud aggregates existing data from all cloud-instances to provide a universal dashboard that displays health status from one or more or all communities currently registered in the system.

B. *Data Entry Procedure*

Originally, input comes from 2 types of users: the medical professional (i.e. midwife, nurse, MHO), and the Mayor. A third type of user referred to as an encoder was added to the operational scenario. Ideally, eTABLET users per municipality consist of one Mayor user and multiple medical professionals and encoders. For the pilot phase of this project, however, there is one Mayor user, one medical professional (assigned nurse or MHO) user, and several encoders. Medical professionals may enter patient medical record data, consultation data, and special requests to the Mayor. The Mayor user in turn may enter instructions through a Mayor Instructions feature as part of the Doctor-Mayor subsystem of the eTABLET. Encoders are given access to the eTABLET auxiliary website for encoders, where patient medical record data may be entered, not inclusive of consultation data. There is a set of these types of users per municipality, and the data they enter either through the eTABLET application or the auxiliary website (for the encoders) are aptly saved in the exclusive cloud instance assigned to their municipality.

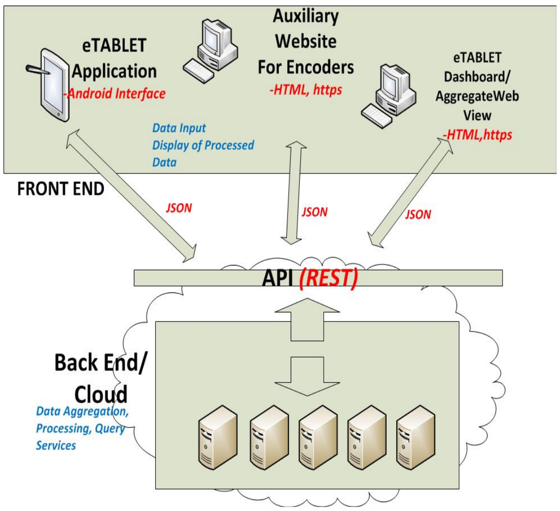

Fig. 1. Development Framework

C. Reports generated by the system

The report feature allows users to generate a ranked list of diseases, bar graphs illustrating quantities of diagnosed diseases, pie charts illustrating percentage comparisons of diagnosed diseases per municipality, and disease trends via line graphs. These visualizations are generated by aggregating data that have been entered using the patient medical record facility of the eTABLET Application. This implies that the visualizations are information processed from patient data, hence its potential value is dependent on the amount of data entered by the users prior to generating the graphs. The system was designed to able to generate real time aggregated morbidity reports of selected communities.

Figure 1 shows a schematic diagram of the system designed for a multi-stakeholder user environment.

Google Maps were incorporated to provide a quantified and geographical perspective of diseases. The system can generate a spreadsheet version (in xls format) and a portable document version (in PDF format) of selected reports mandated by the Department of Health (i.e. Malaria, Tuberculosis etc.) following previously approved templates. Similar to the graphs, reports are derived from available data entered by the users prior to the generation of the reports.

D. eTABLET Web View

The eTABLET Web View is a website that serves a health dashboard with customized maps and graphs. Users are able to use a map view to locate areas of disease incidences along with specific quantities, generate bar graphs, pie charts and line graphs, including the generation of a ranked list of diseases per municipality. These are features that are essential to actual reports submitted by municipalities to the regional, provincial and national offices. The difference is that the Web View is not locked to any one municipality, rather, the backend processes of eTABLET Web View aggregate the data from all the cloud instance servers of each municipality to illustrate the general status of the volunteer sites.

IV. Results

A. Design Perspective

The intended users of the system included: local health officers, Mayor, provincial, regional and national representatives who need to access aggregated information related to health. In a multi-stakeholder environment, gathering of requirements for customization was conducted on a regular basis (weekly meetings, monthly visit to sites) to ensure that a full grasp of the system is obtained. Other methodologies as inputs to the design included: time motion studies, technology adoption survey, and integration workshop between and among stakeholders. The first set of screens were created by a third party group after being presented with initial user requirements. There were a total of 5 versions of the system with each version incorporating revisions: 1) in screens to match workflow, and 2) in features (save and synch, save and email, including web input, usage monitoring).

B. Development Perspective

The project manager conducted weekly meetings with the developers to ensure that all requirements, based on recommendations from the respective users, are incorporated in the new version.

1) Patient Medical Record Data Input: Patient Medical Record Data Input is the key functionality of the eTABLET Application that facilitates the increase in the potential value of eTABLET output. The items included in this functionality are based on basic EMR (Electronic Medical Record) components, such as deconstructed patient name and address, patient identification number and personal data inclusive of birthday, gender, and title. The items were validated by Paombong and Anilao sites.

2) Consultation Data Input: Consultation Data Input was based on the SOAP (Subjective, Objective, Assessment, Plan) format followed by the paper-based forms of the Anilao, Iloilo site. These inputs include standards in medical check-ups such as chief complaint, vital signs, lab tests and results, diagnosis and treatment. The lab tests follow the LOINC standard incorporated in the eTABLET Application, while the diagnosis ontology follows the ICD10 standard included in the eTABLET Application as well.

3) Multiple Disease View: Multiple Disease visualization with bar graphs, line graphs, and pie charts, are part of the Graphs and Charts functionality of the eTABLET application. The potential value of the output is anchored in the amount of patient medical record and consultation data that have been entered through the aforementioned Patient Medical Record and Consultation functionalities.

C. Deployment Perspective

The 10 sites were pre-selected based on recommendations from the technical working group. These sites are located in the three main islands of the country, namely, Luzon, Visayas and Mindanao.Deployment scripts were made so that each deployment is consistent. Script suite was composed of a presentation file containing the rationale of the project, followed by a demonstration of the system. After the presentation, the team then hands over tablets to the doctor and mayor or their representatives. Email accounts are created so that communication is sustained after the team leaves the site. One page manuals and daily usage guide were also provided to sustain the use of the system. All users were requested to post their status on a public forum dedicated to eHealth TABLET users.

1) Full Version Deployment: Data entry via the patient record, consultation and diagnosis module as well as the reporting module is present in the full version. Report generation included specific submissions required by government health programs. To make reporting more efficient, features such as saving in readable formats were made available. Local saving is a feature added such that users can save incomplete sets of data in the eTABLET specifically to address issues on intermittent Internet connectivity in some areas. Revised features that have been requested by the users of the volunteer municipalities include alerts whenever there are new inputs to the eTABLET Application via the Doctor-Mayor Communication subsystem (i.e. Doctors Special Requests and Mayors Instructions) and augmentations in filtering patient records.

2) End-to-End System: While the full version fulfills the data entry and data display requirements. The Web View was created in order to fulfill the objective of real time display of aggregate information. The eTABLET Web View is an off-tablet visualizer of aggregate data that aims to show the user the state of health of the nation within the context of the eTABLET data scope and municipality coverage. At the same time, the Auxillary web entry was created in response to the difficulty of entering patient data via the tablet. Web entry of patient data is facilitated by the Auxiliary Website for encoders. This facilitates the retroactive and/or batch loading of patients into the system by encoders through a web interface. Monitoring is performed by observing the behavior of users in the eHealth.ph forums, where communication takes place between point persons from each volunteer municipality and the eTABLET team. In order to know the usage of the eHealth TABLET, which is a measure of its adoption and effectiveness, a mobile monitoring application was created. A more automated way of monitoring is facilitated by an eTABLET Monitoring Application, in which the latest iteration is able to track the number of patients, consultations, diagnosis, activities (bar,line,pie, and map generation) , and doctor-mayor communication through aggregate data pulling across the cloud instance servers for each municipality.

V. Lessons Learned

Information Communication Technologies has been recommended as a possible solution to recording of patient data in remote areas and in providing quick access to patient information. In a third world country such as the Philippines, managing the development and deployment of mobile-cloud based applications still presents a challenge in terms of time management and user feedback. The ideal scenario is that since the system is basic in all rural health units (electronic medical record with diagnosis and reporting features), customization can be general. However, our experience shows that other factors such as experience in using other systems, aggressiveness of leaders (doctor or mayor), and public perception based on transparency reports lead to better adoption of the system. The system was not done in isolation and is still a work in progress. Several deployments led to several iterations which gave way to the inclusion of unplanned functionalites such as providing alerts to mayor and doctor if requests are made, saving reports to printable files, creation of web auxillary data entry and generation of usage reports, are all evidences of evolving innovation. This experience shows us the project management for systems that are to be used by a large population (in this case, nationwide) must be user-centric because specifications evolve as users embrace the system.

Acknowledgment

The authors would like to thank our partners: Department of Science and Technology (DOST), Philippine Council for Health Research and Development (PCHRD), Institute of Philippine Culture (IPC), Ateneo de Manila University, SMART Communications, Inc., League of Municipalities of the Philippines (LMP), and the Ateneo Java Wireless Competency Center (AJWCC).

References

[1] Sasikanth Avancha, Amit Baxi, and David Kotz. Privacy in mobile technology for personal healthcare. *ACM Computing Surveys*, 45(1), 2012. doi:10.1145/2379776.2379779.

[2] Mary Jo Baisch. A systematic method to document population-level nursing interventions in an electronic health system. *Public Health Nursing*, 29(4):352–360, 2012.

[3] Elaine Byrne and Sundeep Sahay. Participatory design for social development: A south african case study on community-based health information systems. *Information Technology for Development*, 13(1):71–94, 2007.

[4] Ma. Regina E. Estuar, Dennis Batangan, Andrei Coronel, Anna Christine Amarra, and Francisco Enrique Vicente Castro. Bottom up approach and devolved design of a health information system: ehealth tablet. *Lecture Notes in Artificial Intelligence*, 8211:210–217, 2013.

[5] David Kaufman, Wm Dan Roberts, Jacqueline Merrill, Tsai-Ya Lai, and Suzanne Bakken. Applying an evaluation framework for health information system design, development, and implementation. *Nursing Research*, 55(2):s37–s42, 2006.

[6] Inez Mikkelsen-Lopez, Kaspar Wyss, and Don de Savigny. An approach to addressing governance from a health system framework perspective. *BMC International Health and Human Rights*, 11(13), 2011. doi:10.1186/1472-698X-11-13.

[7] Wilbroad Mutale, Namwinga Chintu, Cheryl Amoroso, Koku Awoonor-Williams, James Phillips, Colin Baynes, Cathy Michel, Angela Taylor, and Kenneth Sherr. Improving health information systems for decision making across five sub-saharan african countries: Implementation strategies from the african health initiative. *BMC Health Services Research*, 13, 2013.

[8] Shainur Premji, Ann Casebeer, and Richard E. Scott. Implementing electronic health information systems in local community settings: Examining individual and organizational change experiences in the philippines. *The Electronic Journal Information Systems Evaluation*, 15(2):186–197, 2012.

[9] Bahlol Rahimi, Vivian Vimarlund, and Toomas Timpka. Health information system implementation: A qualitative meta-analysis. *Journal of Medical Systems*, 33:359–368, 2009. doi:10.1007/s10916-008-9198-9.