

Borboleta and SaguSaúde - Open Source Mobile Telehealth for Public Home Healthcare:

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Abstract: Healthcare Centers play the role of primary healthcare providers under the Brazilian Unified Health System (SUS). One of its relevant activities that is proving to be effective in increasing the quality of life of the population is home care. To further improve the quality of the health service provided by these public programs, we are developing an integrated system composed of a mobile module, Borboleta, and a fixed module, SaguSaúde. They support a mobile Electronic Health Record system that can be accessed both via smartphones in the homes of the patients and via a desktop with a regular Web browser in the Health Center. As we cannot count on Internet connectivity in the patient's home, the system supports a replication and synchronization process to provide offline data access for both reading and updating health information.

Introduction

Healthcare Centers play a major role in the Brazilian public healthcare system as they are responsible for the primary healthcare in their geographic region. Governmental initiatives such as the Family Health Program have produced very significant results in the improvement of health indexes by focusing on preventive medicine. In these programs, health professionals and specially-trained community agents visit the homes of patients (mostly in low-income neighborhoods) to provide health services. However, at the current stage, these actions are carried out with almost no support from Information Technology. All the data is hand-written in forms that are stored in piles of thousands of pages of paper that are hardly ever used for any significant health action or study.

The Borboleta project conducted by the University of São Paulo, Brazil, aims at developing a mobile Open Source Integrated System for

management of health information in the context of public Healthcare Centers and home healthcare service. The hypothesis we want to verify is that automating data collection and processing can improve significantly the quality of the service provided to the population. To achieve that objective, the system we are developing includes a multimedia electronic health record (EHR), which stores patient personal and health data, including treatment history. The mobile EHR improves the quality of the health service, facilitating access to patient health information and guaranteeing that less data is lost due to hand-written records that are not processed. It also brings the opportunity to study the evolution of diseases as the health information database is linked to temporal and geographical information.

System Architecture

The system is composed of two major parts: Borboleta, that runs on smartphones, and SaguiSaúde, that runs on the Healthcare Center. During home care, health professionals visit patients carrying smartphones with Borboleta to consult the patient's historical health records and to collect new information. SaguiSaúde is responsible for centralizing health information of all patients and making it easily available for health professionals. Different from existing IT systems for primary healthcare that focuses mostly on billing, the goal of SaguiSaúde is to improve the quality of the health service that is provided. Developing such a complex and innovative system in which the requirements are not completely known is a challenge.

SaguiSaúde - the Central Module

SaguiSaúde is developed as a Web system using the Ruby on Rails framework and is accessed by health professionals via commodity Web browsers. It is composed of three main modules: users registry, health appointments, and administration. Users registry contains personal and socioeconomic data of users, including patients, doctors, nurses, and other Healthcare Center employees and community members. Everyone is seen as a user in the system and their specific types and relationships among them are represented with its specific semantics. The health appointments module contains scheduling and history of health appointments. One can search records by user name, registration number, and/or date. A health appointment record contains written and oral notes from the health professionals taken during a visit and they cover issues such as the patient's health situation, daily activities, environment, treatment, and illness evolution. We try to keep this data structured as much as possible, but

wherever it is necessary we give to the health professional the opportunity to register stories as free text or oral reports.

The administration module is divided into two parts: support data and management. Support data comprises the set up of static data, including diseases, drugs, streets, religions, types of documents, education levels, etc. We never couple these data with static codes so that we can evolve the system just by reconfiguring it. There is not yet in the Health community a clear agreement about the terminologies to be used; making these data rigid would practically preclude the adaptation to Healthcare Centers in other contexts, for example, in other Brazilian state or another country. The other part of the administration module comprises user management and fine-grain access control. A major concern during the development of a health system must be security and privacy. SaguSaúde manages sensitive data, and needs to assure that only permitted users will have access to these data. To achieve this, the system has a role-based access control module that gives the administrator the ability to manage users and what data each one has access to.

Borboleta - the Mobile Module

The Borboleta module aims to be a mobile Electronic Health Record system, which runs on smartphones and PDAs, replacing the paper forms that were used before. In this manner, health care providers gain mobility, because a mobile device is smaller than a bunch of paper forms, and agility, as the system is optimized to not need so much typing on the inputs.

The module carries a subset of the information stored in the central database. This subset is defined based on the homes that are visited in a particular day, and the data is transferred to the mobile system through the WiFi network of the Health Center. After this step, Borboleta works disconnected from the central module, as at the patient's home, the health professional has no network access. At the end of the day, the health professionals go back to the Health Center and synchronize the collected data.

The module is implemented on the Java ME platform using the LWUIT framework for the graphical user interface to achieve a more uniform look and feel across different types of smartphones and operating systems.

Synchronization

The synchronization process is composed of three phases: replication, evolution, and reconciliation. In the replication phase, selected records are copied to the mobile device and, when applicable, data locks are applied. Data locks are meant to avoid data conflicts when a record can be updated

in more than one device while replicated. Another approach is to tolerate data conflicts, treating them during reconciliation, resolving automatically or with human help. In the current stage, we assume there will be no data conflict as this is consistent with the current use of the system. We assure this by replicating records as disjoint sets between mobile devices and reconciling it right after the home visits. The evolution phase happens when local updates are applied to the mobile database, during home visits. In the reconciliation phase, updates are propagated from the mobile module back to the central database, a PostgreSQL database in our case.

During the development of Borboleta and SaguSaúde we realized that it would be difficult to maintain exactly the same data model for the mobile and central databases. Having heterogeneous data models enables the independent development of both systems. However, synchronizing heterogeneous databases implies the addition of another step in the replication and reconciliation phases: data transformation. The synchronization process is implemented as module of SaguSaúde and it is responsible for transforming data from the central to the mobile model during replication, and back to the central model during reconciliation.

The synchronization protocol was implemented based on REST (Resource State Transfer) over HTTP, representing data as XML documents. For the data transformations we have used XSLT (eXtensible Stylesheet Language for Transformations).

Results

The software is currently being developed using an Agile Methodology in which preliminary versions of the system are tested by real doctors and nurses monthly and several releases are produced each year. Although SaguSaúde and Borboleta are not yet in production, some of their modules are already usable and tests are being conducted with a 120,000 people database from the University Healthcare Center. The system is available as open source software and is freely distributed under a BSD license from <http://ccsl.ime.usp.br/borboleta>.

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