

A Data Synchronization Model in Mobile Electronic Medical Record for Operational Efficiency

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Abstract

In today's world, technology has been growing exponentially. This is seen most especially in the field of mobile technology, specifically with smart phones. However, there are still parts of people's everyday lives that have not been influenced by mobile technology, the hospital industry. Communication between doctors and consultants are rudimentary. They communicate patient information either via paper or just via SMS. Although this is still a functional way, availability of the information is limited and its safety is vulnerable. In this study, we have developed a data synchronization model so that doctors and consultants would be able to access the patients' medical record via a mobile application while preserving data integrity and improving operational efficiency. We have conducted a series of face validations with doctors and consultants to improve the usability of the system. Initial results show that the application can already be piloted for use in the hospital environment. Future work includes conducting a thorough usability study on the actual usage of the system in the hospital environment and implementing other important features as will be verified in the pilot testing.

Keywords

Data synchronization, healthcare systems, electronic medical record, operational efficiency

1. Introduction

This study aims to address the problem of the lack of relevant and usable systems for use in the healthcare industry. It aims to find a way to address the problem on how healthcare services can be provided faster and efficiently to the patients in the hospital scene. This study also addresses problems faced by developers in creating an efficient information system on a mobile platform for patients, something that has not been fully explored in the current scenario today.

In a normal private hospital setting, information regarding a patient is manually done and recorded. It is written on paper using the forms that are a standard and stored in files in the establishment. In advanced hospital establishments, this information are stored and viewed on a database system that can be viewed on a computer. Inputted by assigned personnel using these papers filled up by nurses and doctors, patient information is stored digitally in this system. Though somewhat effective, it will still take time for a doctor to open up a PC (Personal Computer) and access his/her patient's data from there. This could be a problem should the patient need immediate medical attention and the doctor has to find a PC and access the patients information before he/she can be properly informed as to how to deal with the patient. And the doctor might not even be able to find a PC right away because other doctors are currently using them. What is worse is that due to this delay, the patient may have already been in a better condition if attention was given right away. Although it can be proposed that at each hospital room, there could be a PC in each to solve this problem, it is much too costly and bulky. Thus, this study proposes to fix this problem. This study proposes to utilize mobile technology to provide patient information to the doctors in a faster way. Mobile technology is now mainstream and also exponentially advancing, even as you read this text. Hence, it is just advisable to use something that is technologically advanced or hi-tech, but also easily accessible to all, seeing as almost each one of us has mobile phones. The proposed solution would be to use these mobile phones,

specifically the smart phones, to be able to view a patient's information. This way, the attending doctors would not have to run and find an open computer and access patient information; they would just have to open their smartphones, connect to the network and access the patient information from there. Medical attention, then, could be given right away to the patient and they could be saved in life threatening scenarios.

The problems that will be addressed in this study are the following:

- (1) The need for a mobile web application in a specific mobile platform to serve as a User Interface to be able to view Patient Information.
- (2) The need for an effective synchronization system to be able to address the issue of having more than one user using the system to access and update in-formation.
- (3) The need for the right and useful information to be displayed on the mobile web application stated above.
- (4) The need for this information to be available when not connected to a network.

To address the problems stated above, this study proposes to create a patient information system using a mobile web application that can provide useful and updated patient information to the target users, i.e. doctors. This system would have the following features:

- (A) Mobile Web Application (Using the Android Mobile Platform)
 - (1) Sync with Online Central Database
 - (2) Access Only Assigned Patients Using A Login System
 - (3) View Assigned Patient/s Information
 - (4) Add/Edit Assigned Patient/s Information
- (B) Web Service
 - (1) Add/Edit Patient Information to Central Database
 - (2) Assign Patient to Doctor

2. Related Works

1.1 Hospital Information Systems

One of the main objectives of this study is to utilize the existing rapid advancement of today's technology and use it in such a way that is beneficial to the field that we are tackling in, the Hospital environment. One of the existing technologies today is the use of Information Systems to keep and organize data and information electronically. In contrast to the technology of old which used papers and cabinets to keep their records in, today's technology have us saving physical space and saving papers and cabinets, all the while still keeping the same data and information.

This technology involving Information Systems has also found its way into the Hospital scene. A study of Hospital Information Systems, especially on electronic patient records, conducted by Pedro Luiz Cortes and Eliana Golfette de Paula Cortes, respectively from the University of Sao Paulo and Universidade Gama Filho in Brazil, deals with the question of "what are the benefits and problems that can be seen with the use of electronic versions of medical records?"(Cortes & Cortes, 2011) As stated in the question, their study involves finding out the advantages and disadvantages of a Hospital Information System in the hospital establishment. And based from the surveys they have done, it is found that the benefits of having a Hospital Information System include the standardization of processes and ease, agility of recovering patient information, and better control over prescriptions and procedures. But aside from the benefits, disadvantages were also found such as the difficulty in organizing the information on the screens of the system and also, interruptions of the system. Also, in a different but related study by Tricia L. Erstad, benefits of having an information system can save several people from doing the same work that others have already done. In conclusion, having this system can save time. Also, it is discussed in that study that one of the barriers or challenges of having a Hospital Information System is the cost of having one established in a Hospital. Also, another is that compared to other sectors in the economy, the healthcare industry is not that committed to interactive information exchange.

But despite all the advantages and disadvantages of having a Hospital Information System, as stated in the study by Pedro Luiz Cortes and Eliana Golfette de Paula Cortes, the benefits do outnumber the disadvantages.

1.2 Use of Mobile Applications (Android Platform)

Now that we have established that a Hospital Information System can be beneficial and helpful to the Hospital/Healthcare sector, the next challenge we have to discuss is "how do we implement it?" or "what new and widely-used technology can we utilize for this information system?"

The times of today have shown that one of the fastest growing modes of technology is the Mobile/Smart Phone technology. According to a web site (www.brandwatch.com), statistics show that in just America itself today, 56% of their population now owns a smartphone. In the Philippine scene as of the fourth quarter of the year 2012, 14% of the Filipinos own a smartphone. It is also mentioned on this web site (thebobbery.com), that in that same period, the growth of smartphone subscribers in the Philippines is at 38%, which is 17th out of all the countries. As mentioned in a study by Sawsan Alshattnawi, a faculty from Yarmouk University (Alshattnawi, 2013), this rapid increase of mobile computing technology, where mobile phones are used not only just for making calls, has massive potential for providing access to different services at any time and from anywhere. Smartphones can allow you to access several applications and services using the internet or by using stand-alone applications that do not require internet to work.

This study by Alshattnawi is focused on using this advancement in mobile computing technology as a platform for building Mobile Tourist Guide Applications and deciding on which platform should be better for developing this application. A Mobile Tourist Guide Application is an application that uses the internet to retrieve map information from an online database and displays this information on the smartphone, which the user can access almost anywhere and at any time.

This study also investigated that in a sample population of 70 tourists, the platform they would prefer to use is the Android platform, which won over other platforms like the Symbian platform, Windows platform, and others. Also on a side note, according to the IDC (International Data Corporation) website (www.idc.com), the 2nd quarter market share of Android platform users in the year 2013 is at 79.3%, with the iOS platform coming 2nd at only 13.2%. In the Philippines, using a tool named Statcounter, which counts the number of page hits per type of mobile operating system, the percent of users of the Android platform is at 33.9%, which is followed by the iOS at 19% for the month of December in the year 2012 (statcounter.com).

To relate this to a hospital setting, an Android mobile application would be a good place to start from in developing the Hospital Information System that can utilize a rapidly growing advancement of today's technology, the smartphone. That way, the doctors can access his/her patients' information much like how the tourists can access map information using the Mobile Tourist Guide Application, anytime and anywhere.

1.3 Synchronization

Building the application can be a challenge, but it is not impossible. Due to today's technology, one can easily find guides on the internet that one can use in developing applications with similar functions and just utilize this. Much like the Android platform, forums, discussions, and help can be easily found on the internet regarding building an application.

But unlike the tourists where one can only view the information on his/her smartphone, a hospital information system can involve the doctor adding some inputs regarding his/her patients. This involves communication between the smartphone and the online database that is storing the data on the internet. And because of this, one great challenge that we are facing when building the application is synchronization.

Synchronization, as mentioned earlier, needs the device to be connected to the internet to allow information shown on the device to be updated to what is in the online database. This will work perfectly normal if we are always connected. But if we get disconnected from the internet, or if the connection is cut in the middle of synching, we will now be having a problem with the credibility of the information that is shown to us on our devices, i.e. smartphones, where we can view the information.

To address that problem, a related study done by Isak Shabani, Betim Cinco, and Agni Dika (Shabani, I., et al. 2012) introduces us to an algorithm to address this issue during an absence of network connectivity. In their study, they are addressing concerns with their "Electronic Student Management System" (ESMS), an information system that holds the records of the students in the University of Prishtina (UP). The main concern is that the school has an uncertain supply of electricity, so naturally, outages and network disconnections are inevitable in their environment and their professional staff that manages the performance of the ESMS has their work interrupted because the ESMS is originally an online system and thus, online work cannot be done in cases of network outages.

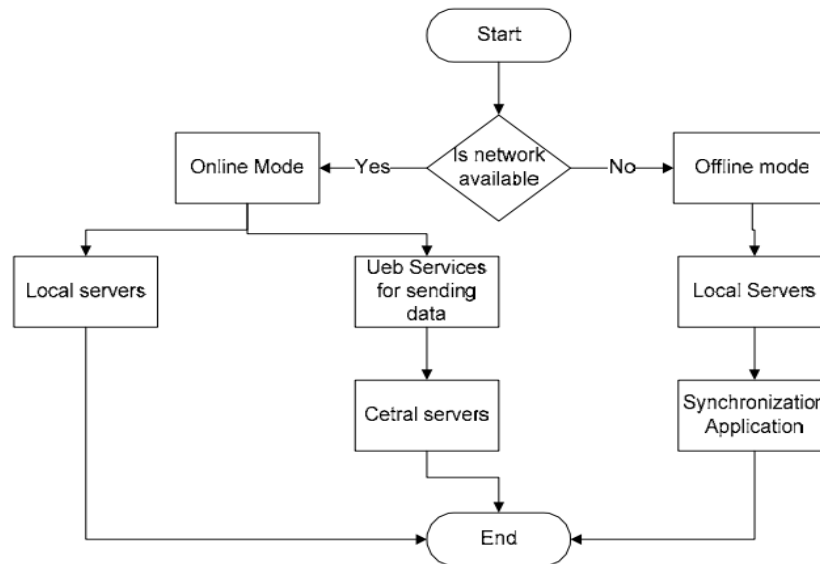


Figure 1: Algorithm for Data Synchronization in ESMS (Shabani, I., et al., 2012)

To fix this concern, they developed an algorithm (See Figure 1) that utilizes an “Offline Mode” for the system where the staff can still do work even if the internet is down. In summary, this “Offline Mode” allows the professional staff to do work, input student records; update student information; and other basic functions for a Student Management System on a local server. Then, using a Synchronization Application, this local server is then synched to the online server when the internet connection is re-established so as to update the online server with any of the changes done on the local server and thus, synchronization is properly achieved and the information provided is now credible.

3. Proposed System

3.1 General Architecture

Figure 2 shows the high level view of the interaction between the users, the doctors, and the mobile web application. The Doctor uses his/her mobile smartphone to login his credentials and view the Patient Information of the patients assigned to him/her. The Phone, the mobile smartphone, uses its user’s login credentials to verify if the user is allowed to view the Patient Information and then proceeds to display the patients that are assigned to the user by synching to the Online Database provided by the Web Service. Also, when the doctor opts to update an entry of the patient’s information, the phone also syncs these changes to the Online Database so that other doctors assigned to this specific patient can be able to use their Phones to sync to the Web Service and update the information that they are able to view.

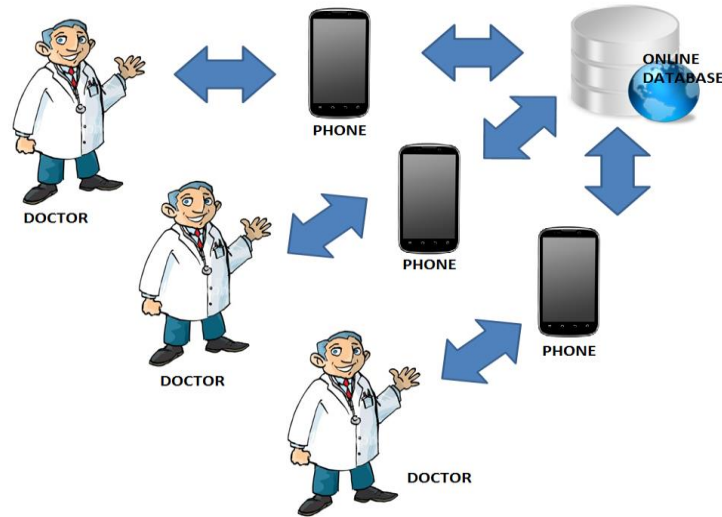


Figure 2: General Architecture Diagram

3.2 System Architecture

The diagram in Figure 3 shows the general view of the algorithm of the general processes in this study. The system architecture diagram above describes the interactions of the actor/client with the application.

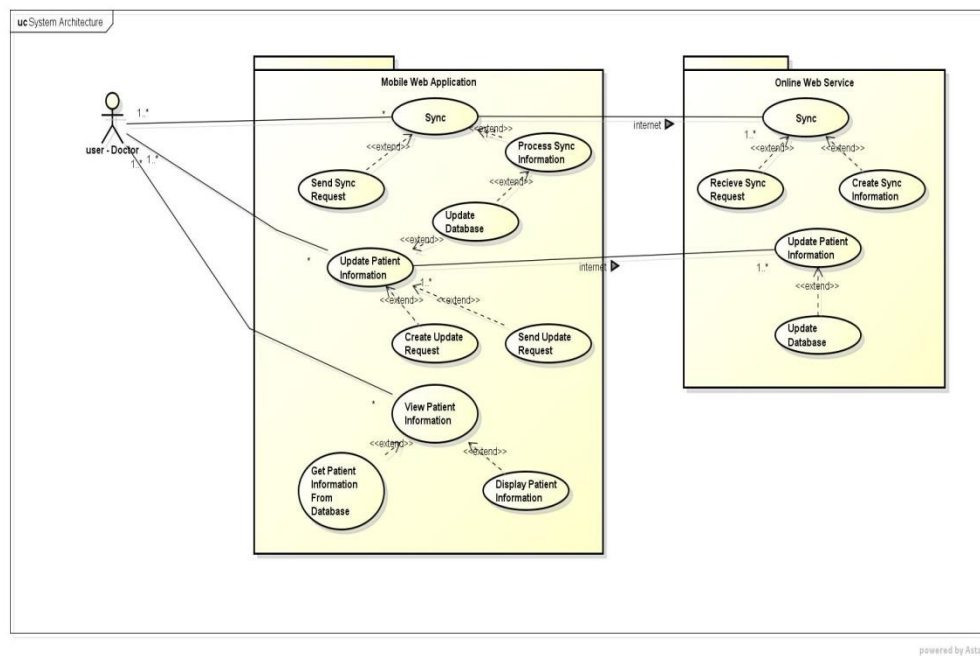


Figure 3: System Architecture

3.3 List of Use-Case Scenarios

- (1) The User can view Patient Information from the Application using his credentials.
- (2) The User can also request Update Patient Information on the Application.
- (3) The User can also request Sync on the Application.
- (4) The Application uses the User's Login Credentials to connect to the online web service and sync its Internal Database with the Online Database in the Web Service.
- (5) When the Application receives an Update Patient Information request from the User, it updates its Internal Database with the request and it forwards this request to the Online Database and updates the entry there.

- (6) The Application can sync with the Web Service's Online Database automatically every 15 minutes or can manually do so with a Request from the User.

3.4 Synchronization Model Used

Figure 4 shows the algorithm on how Synchronization was achieved between the web service's online database (central database) and each of the local databases of the instances of the mobile web applications on the mobile smartphones. In the online database, there exists a sync table. This table contains the records of the changes done to the other tables in the online databases and the time of each of these changes. When sync is requested from the mobile smartphone, this request will also include the time of the request. Also in the online database, a table dedicated to storing the data of the time the smartphone last requested sync to the online database mapped to the specific IMEI number of the mobile smartphone is used to compare the last time the smartphone requested the sync update and the current time of the sync request. These two values are then used to query the sync table mentioned above and return only the changes in the online database that happened between the time the mobile smartphone last synched and the current time that the mobile smartphone requested sync. These changes are then processed in the local database of the mobile smartphones and thus, the information that can be viewed on the mobile smartphone is up to date.

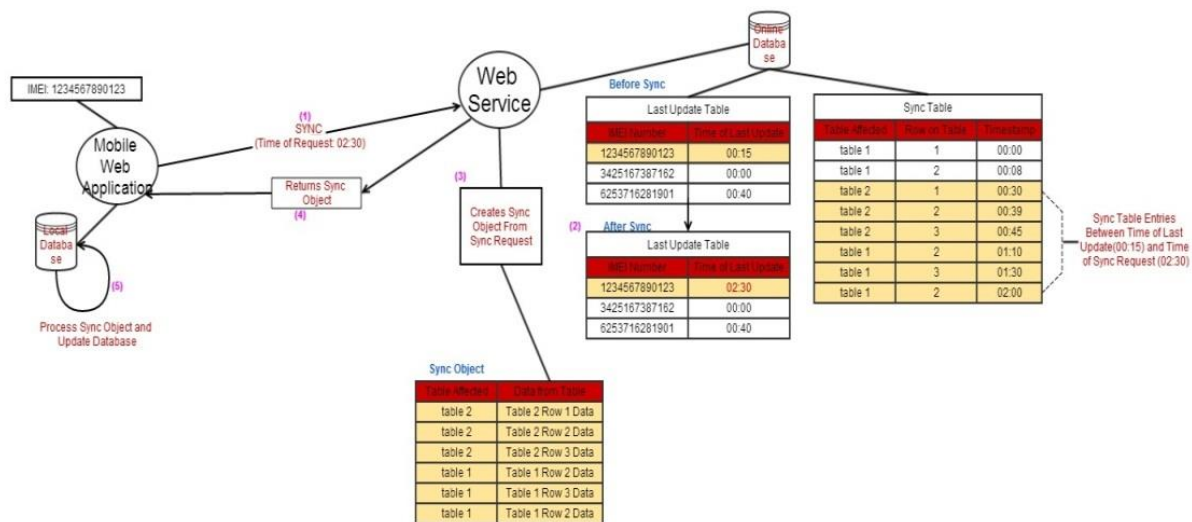


Figure 4: Synchronization Model

We are using this model because it is faster and more effective than sending all information from the online database to the local database. Doing that would entail a lot of data to be processed in the local database and hence, synchronization would take longer than when only the changes reflected between the two times (last update time and current time), which would ensure that only minimal data is to be processed.

4. Results and Discussion

4.1 Initial Approaches

Screens

Initial implementation of the application was provided based from the specifications of a practicing doctor. A meeting was done with the doctor and the researchers present and these specifications were discussed prior to starting development on the mobile application. The screens used in this version was based on these specifications

Synchronization

The first approach tried in solving the concern in having synchronization between the online database and the mobile phone's local database. The implementation involved only syncing the data from the online database only when the user logged-in in the application. This means that the user has to exit the application and login again so as to update the data in the local database.

Also, synching between the two databases was inefficient because everything from the online database was passed to the application for parsing. This means that once the amount of data in the online database becomes larger and larger, synching will take much longer due to the huge amount of data to parse.

Offline Function

The first version did not have an Offline Function. It was implemented with the user always having connection to the internet in mind. This means that the application can only be used if the mobile phone is connected to the internet. It will not be able to run if the phone is not connected to the internet.

4.2 Further Improvements

Screens

The screens for the second version of the application were a bit similar but with a few modifications. Fonts were bigger and much easier to read, compared to the previous version.

Synchronization

A better and faster way of synchronization between the two databases was implemented. Instead of synching everything from the online database to the local database, the Synchronization Model mentioned earlier is implemented. Now, only the changes in the online database from the last time the doctor/user synched to the present will now be sent to the mobile phone for parsing. Hence, synching is now significantly faster than the previous version.

Also, synching is now not done only during a login event. Rather, it is done in the background after every 15 minutes if the mobile phone is connected to the internet. Not only that, the user/doctor can also sync by pressing a button in the Patient List screen. Also, a little display that informs the user/doctor of the time the last synch was done in the mobile phone is displayed in the different screens. That way, the user/doctor can be assured that the information is correct and up to date.

Offline Function

In this version, the offline feature was introduced. And thus, it was duly implemented in the application. The application can run offline and patient information can be viewed by the user/doctor even when not connected to the internet.

4.3 After Presentation with Doctor (Client)

Screens

The screens for this version are now very different from the previous. After presenting the application to another practicing doctor, a lot of changes were made to the screens. Aside from the visible changes, functions to add and modify patient information were requested and implemented.

Synchronization

Due to the request to have a number of patient information to be modifiable, it was also needed to modify the synchronization function because it is now two-way. To address this, synchronization function was improved. Once a modification or addition was done in the local database, these changes were updated in the local database and then sent to the online database for updating.

Offline Function

The problem with having to update the online database with the updates in the mobile phone done by the user/doctor is that it cannot be done when the mobile phone is not connected to the internet. To address this problem, a queue implementation was used in the mobile application. If not connected to the internet and the user/doctor had to make changes, these changes were applied in the local database but also, these changes were added to a queue objects. Once the phone is connected to the internet, and the Sync button is pressed or 15 minutes has passed by, the application will exhaust the contents of the queues and update the tables in the online databases, hence, still achieving synchronization.

5. Conclusion and Recommendation

This study successfully presented a possible solution to the problems raised in this research. A mobile web application was built that runs on an Android smartphone that has served its purpose to be an interactive user interface to view patient information. This information has been checked by a practicing doctor and are deemed important and useful in the normal process of providing proper health care to a patient. Also, the mobile web application is also designed in such a way that this relevant patient information is available even when not connected to the internet by having its own internal database that is synched with the online copy of the main database.

This study also addressed the problem of an effective synchronization system between the internal database of each smart phone and the main online database by utilizing database triggers and using a “sync table” which will return only entries that have been updated since the user last synched with the online database. This, in turn, has made synchronization faster and also allows multiple users to be able to update to the online database and still keep the information’s integrity.

Future work includes conducting a thorough usability study on the actual usage of the system in the hospital environment and implementing other important features as will be verified in the pilot testing.

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Biography

Geoffrey Heredia is a graduating student from the University of The Philippines (UP) Cebu and is taking up Bachelor of Science in Computer Science. He was part of the team that made IRIS, a software engineering class project that is a prototype web site with the objective of catering to the functions of an online student registration and enrollment. He has had more experience in developing using the Java language than any other technologies he has learned, including, but not limited to Android, C, PHP, MySQL, and PostgreSQL.

Kurt Junshean Espinosa is an assistant professor and currently the chairperson of the Department of Computer Science at the University of the Philippines (UP) Cebu. He obtained his Masters in Computer Science from the University of the Philippines Diliman where he was a recipient of the Engineering Research and Development for Technology (ERDT) scholarship. His research interests are intelligent tutoring, sentiment analysis, social network

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Jaime D. L. Caro has over 25 years of experience in education and research in the areas of Computer Science, IT, and Mathematics. He received the degree of Doctor of Philosophy in Mathematics in 1996 from UP Diliman. He spent a year as a post-doctorate research fellow at the University of Oxford from 1997 to 1998. Currently, he is a Professor in UP Diliman's Department of Computer Science. He is the Director of the UP Information Technology Development Center and is an Assistant Vice President for Development of UP. Dr. Caro, also a member of the Technical Panel on IT Education of the Commission on Higher Education (CHED), is a recognized expert in complexity theory, combinatorial network theory, online communities, and e-learning.