

Development of Mobile Platform Integrated with Existing Electronic Medical Records

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Objectives: This paper describes a mobile Electronic Medical Record (EMR) platform designed to manage and utilize the existing EMR and mobile application with optimized resources. **Methods:** We structured the mEMR to reuse services of retrieval and storage in mobile app environments that have already proven to have no problem working with EMRs. A new mobile architecture-based mobile solution was developed in four steps: the construction of a server and its architecture; screen layout and storyboard making; screen user interface design and development; and a pilot test and step-by-step deployment. This mobile architecture consists of two parts, the server-side area and the client-side area. In the server-side area, it performs the roles of service management for EMR and documents and for information exchange. Furthermore, it performs menu allocation depending on user permission and automatic clinical document architecture document conversion. **Results:** Currently, Severance Hospital operates an iOS-compatible mobile solution based on this mobile architecture and provides stable service without additional resources, dealing with dynamic changes of EMR templates. **Conclusions:** The proposed mobile solution should go hand in hand with the existing EMR system, and it can be a cost-effective solution if a quality EMR system is operated steadily with this solution. Thus, we expect this example to be shared with hospitals that currently plan to deploy mobile solutions.

Keywords: Mobile Applications, Electronic Health Records, Information Storage and Retrieval

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I. Introduction

Health IT is recognized as an effective method to enhance healthcare quality and safety and to reduce malpractice. It is necessary to prepare a well-designed and integrated IT system in the Electronic Medical Record (EMR) environment for accurate gathering of patient information with collaboration and communication between organizations [1].

Furthermore, the recent wide spread of Wi-Fi and various mobile devices has amplified the need for mobile solutions. Each EMR system including a variety of clinical process and functions, and mobile solution with quick response, easy accessibility, and immediate responsiveness of development for customer needs has different strategies of deployment depending on the target applications. Generally, in mobile

solutions, the target customers, purposes of services, service concepts, service maintenance, and reaction to customer needs are the top priorities for consideration [1,2]. Therefore, a hospital-centric mobile solution is categorized into functions for healthcare professionals and those for patients.

Functions of a mobile solution *for patients* include information retrieval for care in hospital, inquiry of date of visit, and the provision of simple test results. On the other hand, in case of *for healthcare professionals*, additional functions should be provided because doctors or nurses tend to consider a mobile solution as a part of EMR or mobilized hospital information system (HIS) [2-4]. Thus, the statuses of inpatients, outpatients, or patients visiting an emergency room, as well as the statuses of operating rooms are provided. Also, EMR by patient, results of diagnostic tests, pathology tests, function tests, electrocardiography, picture archiving and communication system (PACS), clinical observation information, intake & output, and communication memos can be retrieved [4]. Additionally, mEMR includes medical notes enabling instant access to patients' records. Using the application programming interface and a phone-embedded camera and microphone, a picture of the affected area of a patient and movie clips of procedures can be inserted in mobile clinical documents. Moreover, this mobile solution can be used as a tool to educating patients or caregivers with multimedia clips and to present electronic consents that patients sign after they are informed of procedures and treatments [1,3,4].

Although satisfaction with mobile solutions *for healthcare professionals* is high, to meet users' various needs and fast changing mobile operating systems is very difficult. Without constant upgrading to keep pace with dynamic changes in HISs, the satisfaction may be reduced. Since many forms and templates are created and items are added or changed based on clinical processes and needs, if every change in templates needs correction in the mobile user interface (UI), it can become a burden to operate a mobile solution in terms of cost and management [1-4].

Severance Hospital started to develop mobile applications for the HP RW 6100 (PDA phone) in 2005, for the Bluebird PIDION (PDA phone) in 2007, and for the BlackJack (PDA phone) in 2008. In 2010, a mobile solution *for healthcare professionals* for the iOS-based iPhone was launched. The development of various applications for various Telcos or mobile devices made it difficult, not only to manage various mobile application source codes but to secure human resources dedicated to upgrade. Therefore, in 2012, Severance's novel mobile architecture was designed to ensure effectiveness in maintenance and operations independent from specific

devices or OSs, to adopt a personal information encryption policy and technology to enforce hospital content security, and to provide integrated management of Legacy EMR and a mobile solution. To verify the safety and the effectiveness of the mobile architecture, the new mobile solution was developed and deployed with a patient list organized by theme and EMR history retrieval as the main service [1,2,4].

In this paper, we describe Severance's new mobile architecture which reuses existing EMR structures to provide services targeting mobile devices.

II. Case Description

1. Steps for Developing New Mobile Solution

A new mobile architecture-based mobile solution was developed in the following four steps.

Step 1: Construction of server and its architecture

We used the server of ASP.NET MVC 4 and Visual Studio (C#) and the client of Xcode (Objective-C). We chose iPad or iPad mini with the iOS 5 version or higher mounted as the client device. The server-client protocol was HTTP and JSON data interchange.

Step 2: Screen layout and storyboard making

To choose target screens in HIS, ideas regarding use-cases of mobile devices were solicited internally for three weeks from potential users.

Step 3: Screen UI design and development

The basic strategy, 'for using without any training' was conceptualized. Therefore, we designed menus and icons to maximize reuse of the HIS' system resource files and applied them to mobile device's UI methods (e.g., two-finger or four-finger flicking) for multipage moving, zooming in/out, signing, or drawing.

Step 4: Pilot test and step-by-step deployment

The scope of the pilot test included a patient list organized by ward and department, EMR documents, and test result (PACS included), 48 hour-clinical observation information, multimedia and voice recording, iPad notes, informed consents, multimedia clips, groupware links, and bedside billings.

After this mobile solution was deployed in inpatient settings for the two-month pilot test, it was expanded to four of Severance's branch hospitals.

2. New Architecture-Based Mobile Solution

An overview of the new mobile architecture-based mobile solution is shown in Figure 1. The mobile server manages user ID and mapping information, as well as department, access log, and authorization information to HIS application server. We managed the conversion module (rule-based extensible markup language [XML] converter) for receiving and sending medical records or information requested from mobile devices as a separate process.

Numbers in the circle represent the process flow within the mobile solution. First, user logs into the mobile solution to access medical records. After the mobile server receives the

medical record request, the server parses the XML formatted medical record and converts it to a specialized mobile formatted document. The mobile formatted document is parsed in the iPad and converted to iPad controls which can be viewed by the user.

The mobile architecture comprises a mobile server and mobile devices. The mobile server receives medical records and information from the EMR system matched with the parameter and then converts the EMR information to fit it to the mobile devices. The mobile devices read and write the EMR and information from the mobile server. Figure 2 shows both an existing EMR and mobile EMR screens of a surgical

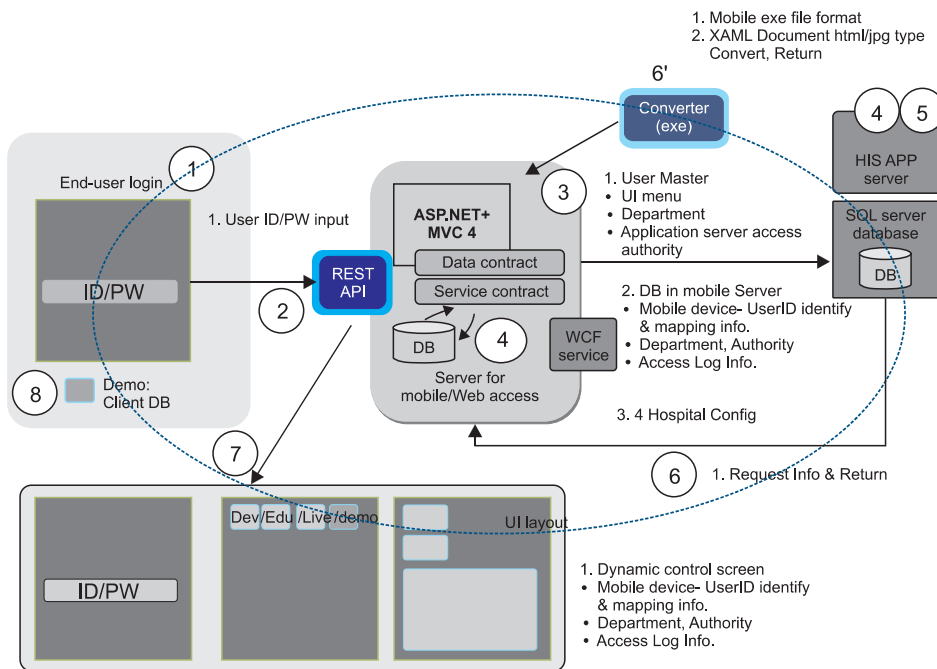


Figure 1. Overview of mobile architecture. API: application programming interface, XAML: extensible application markup language, HIS: hospital information system, APP: application, SQL: structured query language.

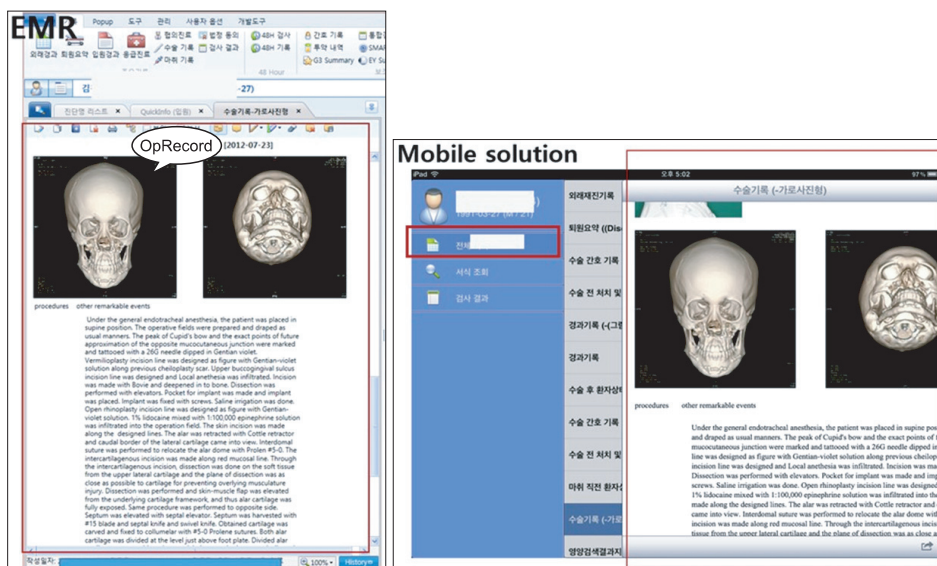


Figure 2. Medical record within the existing Electronic Medical Record (EMR) and mobile solution.

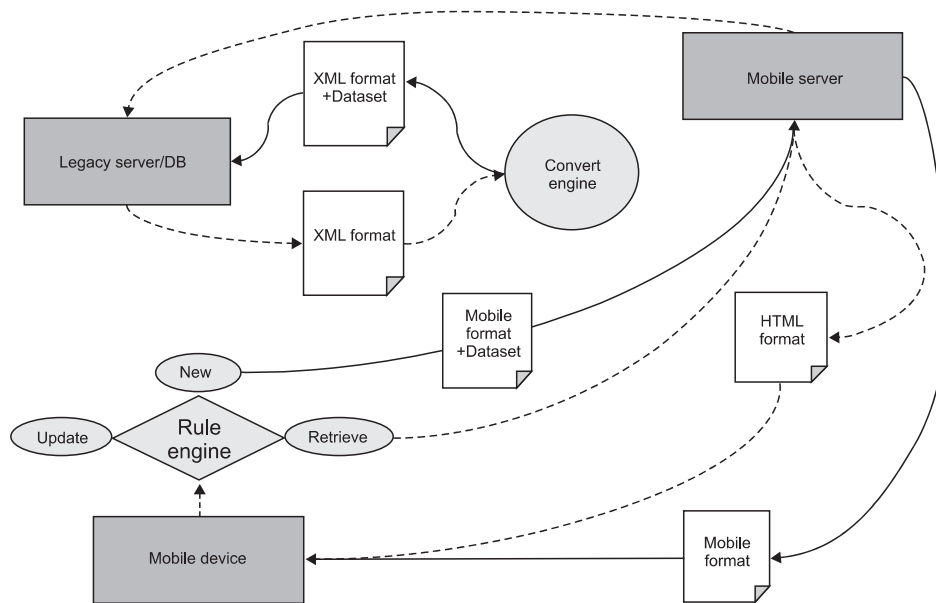


Figure 3. Flowchart of clinical document and information exchange in mobile architecture. XML: extensible markup language, HTML: hypertext markup language.

note that was rendered by the process described above.

The mobile server receives EMRs and information written as XML from the EMR system server, which parses them with the clinical document architecture. Then, it is converted to hypertext markup language (HTML) with the rule of pre-defined recomposing and is sent to mobile devices. In other words, the mobile server receives an XML-type clinical document when requested to retrieve specific records from the HIS. Then, it parses the received XML-type clinical document by the rule of the category master and clinical document architecture, creates an HTML-type clinical document by the pre-defined reassembling rule, and sends it to mobile devices (Figure 3).

III. Discussion

We could expand the EMR system from existing client devices (PC, laptops) to mobile clients, such as smartphones and tablets in the wired-wireless environment by building a new mobile architecture-based mobile solution. In particular, the mobile server functions as a relaying server between an HIS and mobile devices to provide medical records and information as in the existing system [5,6].

The clinical document architecture consists of a header, body, and footer. The body comprises medical record information items, a grid, family history, images/formulae/labels, images, and other templates [5,6]. Also, in the case of writing electronic consent forms and medical notes in the mobile solution, XML template clinical documents are received and parsed to XML-type. After that, a clinical HTML document is created based on the pre-defined rule of recomposing, and

it is sent to the mobile devices. When the mobile devices receive the HTML-type clinical document, they re-convert it to XML-type and send it to the HIS server.

The mobile server parses the XML-type clinical document received and creates an HTML-type clinical document using components, such as radio buttons, text boxes, check boxes, date and hour, drawing or signing tools, and media files, to fit it to mobile devices.

Currently (May in 2014), the number of mobile solution subscribers is 3,173, and the number of average daily transactions is 7,663 (no. of retrieval 1,020/day; no. of recording 536/day).

The proposed mobile solution has the following features. Firstly, it enables users to reuse the template that is created and used in the existing EMR without any further work processes. Also, it enables users to retrieve records (XAML) from the existing EMR system through the converter located in the mobile server. With these features, we plan to use this mobile solution as a contingency system to back up the existing EMR, accessing the DB server of the main system when application servers have trouble.

For immediate response to the changing wired and wireless network environment, various methods, such as virtual desktop infrastructure (VDI) or mobile app development should be adopted when considering hospital policy and the infrastructure of EMR systems. However, the proposed mobile solution cannot be separated from the existing EMR system, and it can be a cost-effective solution if a quality EMR system is operated steadily with this solution. Therefore, we expect this example to be shared with hospitals which currently plan to deploy mobile solutions.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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