A Mobile Healthcare Questionnaire Service Framework using Composite Web Services

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Abstract— **Nowadays there are many healthcare questionnaires which help to check our health status easily. The healthcare questionnaires are, however, usually accessible through Web pages or hardcopies. As a consequence, they have limitations in the aspect of usage. Mobile healthcare questionnaire service is to provide healthcare questionnaires and to deliver the analysis results of the replies from users via mobile devices. Mobile healthcare questionnaire service is one of useful ways to check their health status at anytime and at anywhere. In this paper, we propose a mobile healthcare questionnaire service framework based on composite Web services. Our framework facilitates the designing and provisioning of mobile healthcare questionnaire services through mobile devices and Web technologies.**

Keywords-mobile healthcare questionnaire service, Web services, u-Healthcare

I. INTRODUCTION

Nowadays there are many healthcare questionnaires which have been used as a simple indicator for diseases. As a matter of fact, sometimes and in some cases, we can simply check our health status by answering some questions and summing up the points of the questionnaires, without any help of disease experts. The results of healthcare questionnaires are reliable if the questionnaires are deliberately designed by experts, and the diagnosis results have a strong backup by reliable validations and tests. K.B. Koh et al. [1] introduce Stress Response Inventory (SRI), a stress questionnaire. SRI contains 22 useful questions to collect information to identify stress of a person from the symptoms of users. K. Jongenelis et al. [2] introduce a short version of Geriatric Depression Scale (GDS) which is useful to check if a person is under depression or not. There are many other healthcare questionnaires to check if a person has a possibility of having diseases. Sometimes they provide decisive clues in diagnosing of a disease.

The healthcare questionnaires are, however, usually accessible through Web pages or hardcopies. As a consequence, they have limitations in the aspect of usage. In order to enhance the use of questionnaires in mobile environment, the access ways to questionnaires must be improved so that users can access and reply to the questionnaires at anytime and at anywhere. Such ubiquitous access to the questionnaire service has become possible with the progress of IT technologies. IT technologies enable users to fetch and reply to the healthcare questionnaires on their mobile devices. ***Mobile Healthcare Questionnaire Service*** is to provide healthcare questionnaires and to deliver the analysis results of the replies from users via mobile devices.

There are some studies on questionnaire systems. However, most of them are focused on how to distribute questionnaires to remote participants and gather the information from the replies. K. Morton et al. [3] developed a questionnaire service system for the analysis of target groups. This system deals with the questionnaire results from a group of people is deal but not that of single user. J. Cheng et al. [4] developed a general-purpose questionnaire service system for ubiquitous environment. This system provides questionnaires to users at anytime and at anywhere, but they also targeted the system gathering information from a group of people. In large, the previous questionnaire service studies are inadequate to apply for mobile healthcare questionnaire services that check the health status of users.

Our framework focuses on providing mobile healthcare questionnaire service to users. In this framework users can access the questionnaire services and check their health status at anytime and at anywhere via mobile devices with the support of Web technologies. Applications ported in a mobile device communicate with server side modules through Web protocols. For this, all the components are developed in the form of Web services and sometimes the Web services are bundled to build a composition of Web services for applications. Our framework is not designed just for the delivery of a single health index for a disease. If necessary, it can deliver rich information on the health status of users.

Our framework can be incorporated with other u-healthcare services as well. Many u-healthcare services adopt learning-based diagnosis methods and they often use only bio signals for the diagnosis of some diseases. Our framework can extract and provide many useful features from the questionnaires, so it can help the diagnosis methods improve the accuracies of diagnosis.

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II. Related Work

Mobile healthcare questionnaire service is a new idea in u-healthcare area. Most of u-healthcare services help to care health status of users with bio sensors. D.S. Han et al. [5] uses questionnaire partially, but the research focused on the utilization of bio sensors. The research uses workflow technologies to ease the development of applications, and this point gives some hints to our framework.

In [3] and [4], general-purpose questionnaire systems are introduced. K. Morton et al. [3] describe their questionnaire system in a process model and information model point of view. The purpose of questionnaire system in [3] is to gathering information from a target population by employing Expert System techniques. The questionnaire system in [4] focused on ubiquitous questionnaires, but it also targets collecting information from target populations. The studies are not fit to mobile healthcare questionnaire service, but J. Cheng et al. give some idea as it tried to provide questionnaire at anytime and at anywhere.

III. Mobile Healthcare Questionnaire Service Framework

A. Big Picture

Our framework is illustrated in Figure 1. Since most of components in our framework are in the form of Web services, many questionnaire applications can be easily developed as it is easy to reuse the components developed for other applications. Web services of this framework can be divided into four groups; questionnaire repository web services, questionnaire result analysis Web services, questionnaire history repository Web services and questionnaire history analysis Web services. Questionnaire repository Web services stores and manages questionnaire contents, while questionnaire result analysis Web services analyzes the replies of users and returns the result, such as the possibility of the disease or the degree of related symptoms. Questionnaire history repository Web services accumulate user's replies and the results, and questionnaire history analysis Web services provide other information, such as the changes in the degree of the disease, from the history.

For the more complex and integrated applications, many Web services must be invoked together, but in mobile environment, this job might not be possible because of the limitations of computing power and communication bandwidth. Thus, composite Web services are included in our framework and these Web services are used by most applications. To construct composite Web services, Web services are connected via common message format, Simple Questionnaire Message. The common message format increases the flexibility of the framework by easing the composition of Web services.

Variety forms of applications are possible in our framework. Applications can be ported in mobile devices, or in Web server. The goal of mobile healthcare questionnaire service is, however, to check users' health status at anytime and at anywhere by using questionnaires, so we focus on mobile applications in this paper. Questionnaire editor is a tool to create and edit questionnaires, and this tool invokes questionnaire repository Web services. Service composer helps to create and register composite Web services.

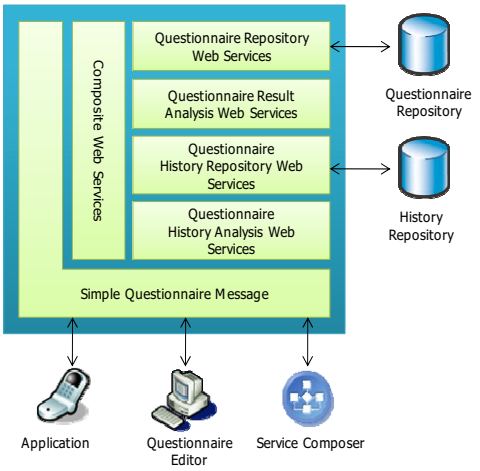

Figure 1. Architecture of Mobile Healthcare Questionnaire Service Framework

B. Questionnaire Repository Web Services

Questionnaire repository Web services are responsible for storing and managing questionnaire contents. That is, questionnaire repository Web services work as the interface of questionnaire repository database. The Web services are invoked when an application shows the questionnaire contents to users or a questionnaire editor manipulates the questionnaire contents.

One Web service in this group must deal with only one questionnaire type because the questionnaires should be stored in different manner according to their forms. For example, questionnaires about mental status are usually objective while questionnaires about workout are subjective, so the designs of database and logics for manipulating the contents are different each other.

C. Questionnaire Result Analysis Web Services

If users answer the questions, the reply must be analyzed and shown to users. Questionnaire result analysis Web services are responsible for reply analysis of questionnaires. The simplest analysis is just summing up the points of each question. The point a user gets can be an identifier for the disease he has. This analysis, however, is not enough for mobile healthcare questionnaire service because users usually want the reason for the diagnosis. To provide more information, various analysis methods are needed and each method is implemented in the separated Web services.

Koh et al. [1] give some hints for questionnaire result analysis Web services. The summed point of SRI is a stress identifier. Furthermore, we can extract 7 stress factors; tension, aggression, somatization, anger, depression, fatigue and frustration, and these factors decide the kind of stress; mental, physical, and emotional. Also we can get the degree of

symptoms related to the stress since SRI asks the symptoms for identifying the stress. Therefore, we can get variety information from single SRI reply, and this information is useful for users.

D. *Questionnaire History Repository Web Services*

For the continuous healthcare service, the framework must keep the history of users' results. Questionnaire history repository Web services stores the questionnaire results and analysis results into the database, and returns appropriate data against request queries. The schema of database depends on the structure of questionnaire, so each questionnaire history repository Web service deals with one type of questionnaire.

E. *Questionnaire History Analysis Web Services*

As the analysis of single questionnaire result gives good information for health status, accumulated results can provide other useful information. By analyzing the history of questionnaires, users can check how their health statuses change. When we consider that many diseases appear gradually with some indications, history analysis can help to prevent disease.

F. *Simple Questionnaire Message*

In this framework, composition of Web services must be easy and dynamic. When a mobile healthcare questionnaire service designer composites Web services, he must match all the in/output with traditional Web services. In our framework, however, designer doesn't need to be annoyed by the task because all the Web services in this framework use a common message framework, called Simple Questionnaire Message or SQM, for their in/output. Web services are connected in pipeline manner with SQM, so Web services can be easily composed without consideration for in/output and they can be dynamically added to or removed from the composite Web services.

The structure of SQM consists of three big parts; questions, results and description. Question part stores the information of questionnaire contents. It is a list of questions and their examples. Result part includes the result of user's selection and all the analysis results. Whenever an analysis Web service is invoked, the result is added to result part. Description part carries some additional information, such as the author, version, and simple descriptions of questionnaire.

SQM must be able to describe the structured data because the questionnaire contents have structures. Since the structures of questionnaires are different each other, SQM must be extensible to cover all the structures. Therefore, in our framework, SQM uses XML technologies. [6] XML is a standardized markup language which is extensible and able to describe complex-structured data.

G. *Questionnaire Editor*

Usually questionnaire designers are experts in medical area, but not in programming. Thus, the framework must provide questionnaire editor which medical experts can use without any knowledge about programming. Questionnaire editor can be any tool for creating and modifying questionnaire contents in this framework. Since our framework uses Web services for managing questionnaire contents, questionnaire editor can have variety forms, such as Web page and standalone application.

H. *Service Composer*

All the components of the framework are developed in Web services, so application designers can implement questionnaire applications easily just by composing Web services. Service composer is a tool to help the composition and execution of Web services. It is similar concept to Business Process Management (BPM) tool. In this framework, however, the number of Web services participated in an application is quite smaller than that in business process, so all the functions of BPM tools are not needed. The required functions are managing Web services in the framework, composing Web services and registering composite Web services. In detail, for managing Web services, the composer must be able to show the list of Web services in the framework and register new Web services to the framework. Also, the composer must provide an easy way to build composite Web services and execute them. Finally, the composer should support registering new composite Web services for later use. Like questionnaire editor, service composer can have any form, such as Web pages and standalone application.

IV. INCORPORATION WITH MUSS

MUSS is short for Mobile u-Health Service System. MUSS integrates mobile bio sensors, Web portal, and mobile devices, such as PDA, to provide continuous and systematic mobile u-healthcare services. MUSS supports two aspects of mobile u-healthcare service; development and execution of applications. MUSS consists of two layers; service platform layer and application service layer. Service platform layer includes disease identification frameworks, development environments, and healthcare service recommendation frameworks to support the development of mobile u-healthcare services. Application service layer ports actual applications, such as stress care and obesity care, to mobile devices.

In MUSS, components developed for new applications are registered in the framework and reused for other applications. For this reason, MUSS uses Web services technology which is the most widely used standard today. Then components are connected by a BPM tool, WebVine™, which is able to recommend appropriate Web services and dynamically coordinate processes. [7]

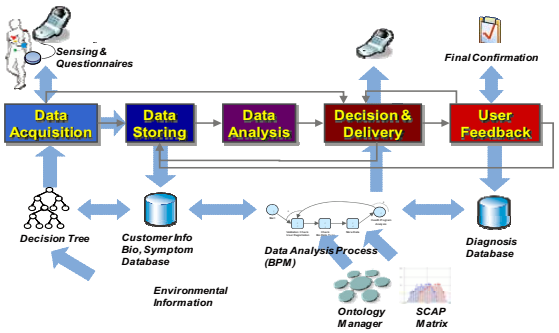

Figure 2. Service Senario in MUSS

Figure 2 shows a service scenario in MUSS. In the scenario, a learning-based framework, Stress Combination Appearance Probability (SCAP), is used for disease identification. It considers pairs of vital-signal and symptoms as basic learning units. Vital-signals are gathered by bio sensors and symptoms are gathered by questionnaire result analysis. In this part, our framework can be used. Our framework analyzes the result of questionnaires and extracts symptoms information which is used by SCAP.

Also our framework helps MUSS by providing other information about users' health status. For example, if we apply above scenario to stress application, the result is a single probability of the stress which comes from SCAP, but our framework provides information such as related symptoms, stress factors and the kind of the stress. By showing the information, users who want to know their health status in detail can be satisfied.

V. IMPLEMENTATION

A. *Web Services*

In our framework, all the components are implemented in Web services based on Axis2. Axis2 is convenient to use because it interoperates with Java and Eclipse which are friendly to many developers, and works on Tomcat which is most widely used open source Web application server.

Web Tools Platform (WTP) is an extension of Eclipse which supports for development of Web and Java EE applications. WTP provide an easy way to create and deploy Web services on Axis2. All the Web services are developed on WTP in this project, but any Web services development tools are possible.

B. *Simple Questionnaire Message*

SQM is a XML-based message format and we implemented the message handler by using XMLBeans. XMLBeans is a technology which generates Java classes from XML schema. We first defined the schema of SQM and generated the handler Java classes by using XMLBeans. The handler provides simple methods for creating and parsing SQM.

C. *Questionnaire Editor*

Questionnaire editor is a tool for creating and editing the questionnaire contents. It can have any form but in this paper, we implemented it in Web pages. The Web pages are implemented in JSP, and they invoke Web services to deal with questionnaire contents. Figure 3 shows our questionnaire editor Web page. When a questionnaire designer changes its contents, the contents in database are updated by invoking questionnaire repository Web services.

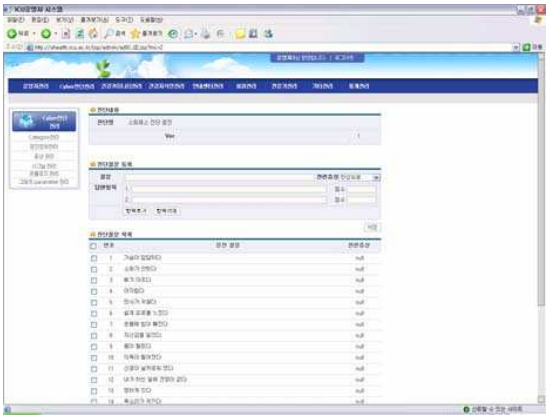

Figure 3. Questionnaire editor Web page

D. *Service Composer*

Service composer is a tool which helps the composition of Web services in this framework. The service composer is a customized version of WebVine™. Figure 4 shows our service composer. The service composer is developed in the form of Eclipse plugin. The service composer supports composition of Web services, execution and registration of composite Web services.

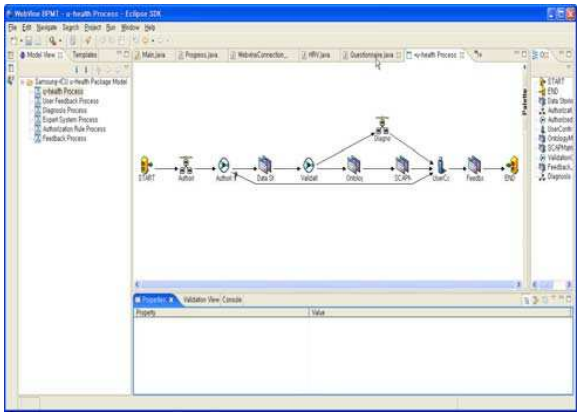

Figure 4. Service composer

E. *Application*

Our framework focuses on the mobile healthcare questionnaire service. In mobile environment, users can check their health status anytime and anywhere. For this purpose, our application is ported on mobile phone. The OS of mobile phone we used is Windows Mobile and the application is implemented in C# .NET Mobile. Since C# .NET Mobile doesn't support Web services invocation, we developed a proxy server, and the server calls Web services. The application is shown in figure 5. Upper left figure shows our application ported in mobile phone, and upper right figure shows questionnaire contents. Lower figures illustrate the analysis results.

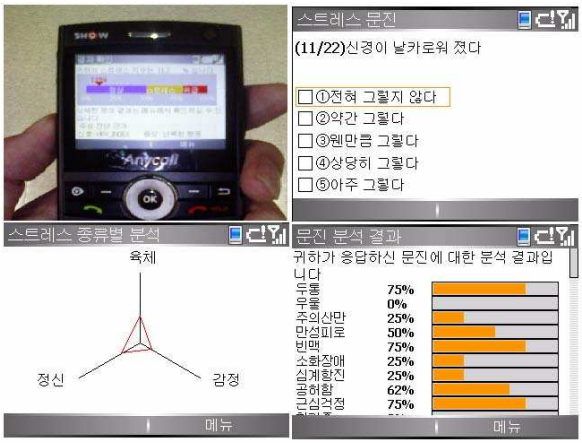

Figure 5. Mobile Healthcare Questionnaire Service Application

VI. CONCLUSION AND FUTURE WORK

We proposed a mobile healthcare questionnaire service framework which uses composite Web services. Mobile healthcare questionnaire service provides questionnaire and analysis results to users with the utilization of mobile devices and Web technologies. With the mobile healthcare questionnaire service, users can check health status easily anytime and anywhere. Since our framework allows variety analysis services, users can get rich information about their health status. Also our framework manages users' history, so checking changes in health status is possible in this framework. Our framework can incorporate with other u-healthcare service which uses learning based methods.

Our framework is focused on existing healthcare questionnaires, but it can give some guidelines for creating new healthcare questionnaires. Questionnaire editor must be extended to provide some helps for creating new healthcare questionnaires. Also, for the developer of applications, service composer must be able to recommend appropriate Web services.

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