Self Risk Assessment and Monitoring for Cardiovascular Disease Patients Based on Service-Oriented Architecture

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Abstract

Risk assessment of cardiovascular disease (CVD) relies on a complex computation from several critical risk factors. To a patient, such factors can be examined at different health providers at different time. In order to efficient access patient's risk factor information from these distributed health service providers, we developed a CVD risk assessment and monitoring system, named CRAMS, that based on the service-oriented architecture. With open standards, such as XML and SOAP, the service-oriented architecture supports interoperability between different platform and application. The distributed health service providers register in CRAMS and provide specific patient information as user demand. In this study, the Framingham heart study is served as the target of risk factors and risk computation model.

1. Introduction

In the past dedicate, the cardiovascular disease (CVD) has became one of the most critical chronic diseases in many countries [1,2]. Therefore, many cohort studies on cardiovascular disease aim to find the interplay risk factors and to build an assessment model based on such factors [3-6]. For example, the absolute risk of cardiovascular disease in any individual is determined by a complex interplay of several factors, of which age, sex, smoking status, blood pressure, and serum concentrations of total cholesterol (TC), high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol are the more important [3]. To people or cardiovascular disease patients, understanding the risk factors and the risk of cardiovascular disease by individual self can motivate the one to change his or her style of living. However, most of the assessment tools and monitoring systems are designed for clinician to use in hospital rather than people to use at home [7]. This is because of clinician can easy to query the people's examinations from patient records in hospital information system. Although there are several systems are developed to support patient to do this assessment, they rely user to input the value of those factors manually [7,8]. Therefore, in this research, we are mainly focused on how to develop a patient centric self risk assessment and monitoring system that supports effective and timely communications between patients, physicians, and other professionals.

Assessing and monitoring CVD risk by patients needs many services from distributive healthcare professionals and facilities. For examples, hospital, individual examination laboratory, clinic, community health station, healthcare device, cardiac physician, professional organization, and so on. All of them are served as health service providers. The decentralized nature of services makes it difficult to develop a single information system to serve all cardiovascular disease patients. Today, Service-Oriented Architecture (SOA) provides an open and standardized way to achieve interoperation between different software applications, running on a variety platforms and/or frameworks [9]. Several researches [10,11] show that SOA is important toward the integration of distributed healthcare service. In this research, we developed a CVD self-assessment and monitoring system that based on the SOA to coordinate the distributed health services for cardiovascular disease patients, clinicians, and other professionals, named CRAMS. When the patient requests service to assess cardiovascular disease risk, the CRAMS asks the services from registered health service providers to provide the target patient's up to date risk factors data. Each assessment results will be stored in the patient's profile. Such risk assessment history data provide patient to monitor his/her cardiovascular disease variation. The clinician can also monitor the patient's risk variation and give suggestions to him/her by the proposed system.

This paper is organized as follows. The Section 2 introduces the proposed service-oriented architecture and system analysis and design. Section 3 presents the implementation environment and result. Finally, a brief discussion and conclusion is given in Section 4.

2. Methods

The SOA emerges basic software architecture principles, such as abstraction, encapsulation, modularization and software reuse [9]. Based on this concept, SOA provides significantly enhanced interoperability between different computing platforms. A service is available at a particular endpoint in the network, and it receives and sends messages and exhibits behaviour according to its specifications [12]. Here, we use SOA, which implemented by web service, to coordinate distributed health related services to patients.

2.1. E-health service-oriented architecture

The SOA for our proposed system consists of four layers (as shown in Figure 1): the web service interface, the service coordinator layer, the quality of service layer, and the health services layer.

Figure 1: A generic model for e-health service-oriented architecture.

1. ***Web service interface layer*** provides open standards, in particular XML, SOAP, UDDI, and WSDL, to achieve interoperability between applications implemented in different computer systems and communicating over a network.
2. ***Service coordination layer*** defines the mechanism of publishing service, finding service, and invoking service.
3. ***Quality service layer*** enables the quality attributes in a health service. Privacy and security are particularly important issues for health service. Patient's health information must be restricted to authenticated and authorized users. Secure transmission such information must be complemented with encrypting data.
4. ***Health services layer*** contains the health services deployed from hospital, laboratory, or clinic.

2.2. CVD risk assessment and monitoring system

As shown in Figure 2, we developed a self risk assessment and monitoring system for cardiovascular disease patients based on the service-oriented architecture.

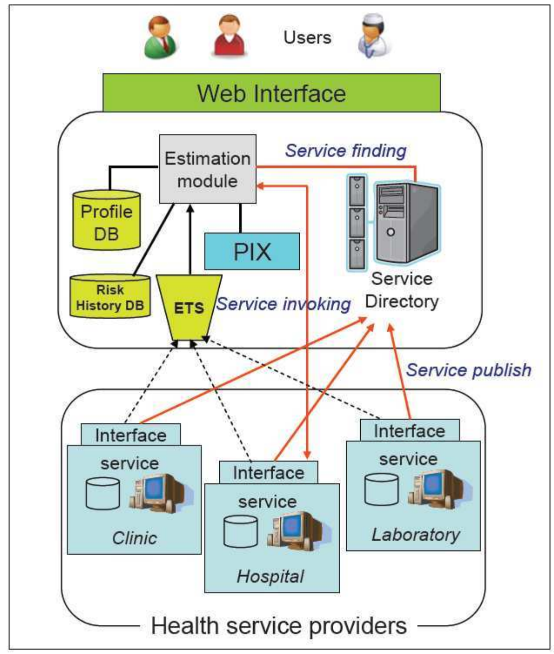

Figure 2: The system architecture of CRAMS.

The main components of CRAMS are described as follows.

(1) Users: The default users include general people, CVD patients, and clinicians.

(2) Profile DB: The patients create their personal profile to store their basic information. For examples, name, birthday, sex, etc.

(3) Estimation module: This module is responsible for assessing the CVD risk according as the risk factors identified in Framingham heart study. These factors can be classified into two categories:

C1: age, sex, diabetes, smoker – pre-declared and changeable by user at each assessment;

C2: blood pressure, total cholesterol, HDL cholesterol, LDL cholesterol – which can be queried from health service providers, such the hospital, clinic, or examination laboratory by blood examination.

Each factor can get a corresponding point value according to its range. And then, a total point that summarized from each factor point can be used to determine the possibility of CHD risk in the coming 10 years (as shown in Figure 3).

(4) Examination timestamp stack (ETS): The system will receive an inform message when patient made a blood examination at health service providers. While a risk assessment requested by patient, the estimation module finds the lasted examination information

from the examination timestamp stack. According to this information, a service request will be sent to the appropriate health service provider.

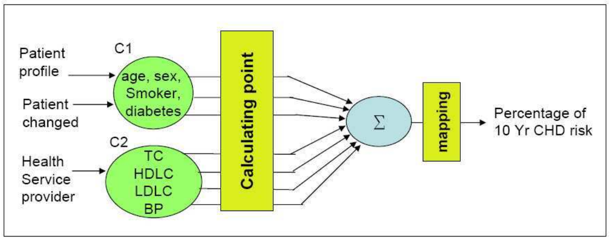

Figure 3. The risk assessment in our proposed system is based on Framingham heart study.

(5) Risk history DB: it saves all the risk assessment results. Such history data can provide further monitoring analysis.
(6) Patient Identity eXchange (PIX): In general, patient's identity is not unified around different hospital or clinic. The PIX component is responsible to find the appropriate patient identity in order to retrieve the patient's examination data (i.e., factors in C2 category) from specific hospital or clinic.
(7) Service directory: It maintains and manages the internet location of registered health service providers.
(8) Health service: An XML-based interface is wrapped to the existed health service application. While patient request to assess the CVD risk, service requests that associated with service location and patient unique identity are issued to the application of health service provider. Then, the application returns the lasted risk factors results to the estimation module.

3. Results

The scenario contained in the proposed system includes two phases: the CVD risk assessment phase and the CVD risk monitoring phase.

3.1. CVD risk assessment phase

A CVD risk assessment is a procedure of mapping and calculation from specific risk factors to possibility of CVD risk. As mention in the previous section, the Framingham heart study estimation model is adapted in our approach. A typical assessment scenario is shown in Figure 4. Estimation module is designed to compute and interpret the Framingham model. Parameters such as age, sex, diabetes, smoker parameters can be found from patient profile database, and partly of them are allowed to change. Parameters such as total cholesterol, HDL cholesterol, LDL cholesterol and blood pressure can be read from hospital patient records or a laboratory test results. Since one patient may take blood examination and blood pressure from diverse health service provider at different time. In order to find the latest examination results, the health service provider should send one message to inform the system while patient took such examination. Examination timestamp stack is designed to manage such messages. The communication between Estimation module and Health service provider is based on Simple Object Access Protocol (SOAP). The Estimation module sands a service request for querying patient's examination data to Health service provider (Figure 5 shows an example of response from health service provider). Finally, an overall risk value that calculated from patient's risk factors is presented to patient's web interface.

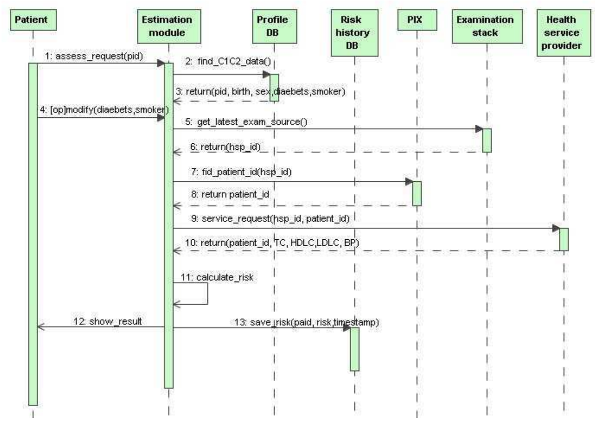

Figure 4. An example of assessing CVD risk scenario.


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<?xml version="1.0" encoding="utf-8" ?>
- <soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:
xsd="http://www.w3.org/2001/XMLSchema" xmlns:soap="http://schemas.xmlsoap.
org/soap/envelope/">
  - <soap:Body>
    - <DeployFactor soap:encodingStyle="http://schemas.xmlsoap.org/soap/
      encoding/">
        <Id xsi:type="xsd:string">F125982892</Id>
        <FactorName xsi:type="xsd:string">TC</FactorName>
        <FactorValue xsi:type="xsd:int">168</FactorValue>
        <ProviderName xsi:type="xsd:string">H001</ProviderName>
        <TimeStamp xsi:type="xsd:string">2008/08/10 11:16:37</TimeStamp>
      </DeployFactor>
    </soap:Body>
  </soap:Envelope>
```


Figure 5. SOAP response message for health service request.

3.2. CVD risk monitoring phase

Continuously monitoring CVD risk factors is important to a CVD patient [13]. The monitoring results can force the patients to change their lifestyle and can also offer the physician adequate information about such patient during the outpatient service. In the risk monitoring phase, the patient's current risk factors and risk estimation result are compared with not only his/she past histories, but also with the people of Framingham study group and the system users (see Figure 5).

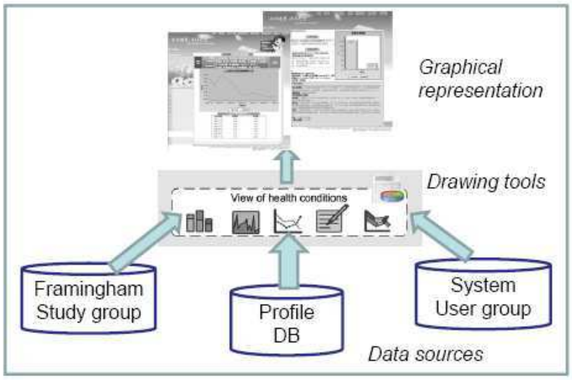

Figure 5. Graphical representation to demonstrate the risk monitoring.

4. Discussion and conclusions

4.1. Discussion

There are two possible approaches to communicating health service providers and CRAMS. The first way is that health service provider automatic pushes the patient's data to CRAMS after every examination patient took. This way has better performance. The second way is that CRAMS requests patient's data on each user demand to health service provider. This way has better liberty and security rather than first way. Both of performance and security consideration are important to a SOA-based system. However, especially in healthcare system, we believe the importance rank of security is higher than performance ones.

4.2. Conclusion

Cardiovascular disease has becomes one of the most critical chronic disease today. An effective and continuous approach to monitoring the risk factors variation can help patients to reduce and follow-up the CVD risk. To most people, the health information is distributed around many health service providers. In this paper, we proposed the using of SOA technology to manage distributed health services for facilitating the risk assessment and monitoring. The main contribution offered by service-oriented architecture is that integrated the distributed service without put them together in real. Any health service provider, who wrapped with a standard web service interface, can easily integrate into the proposed system architecture. It could help the healthcare industry to develop cost effective and dependable healthcare services.

Acknowledgements

This project is supported by National Science Council of Taiwan, ROC contract NSC-96-2218-E-320-006.

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