Chronic Disease Management System Based on eHealth Concept in China

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***Abstract*—Chronic diseases have posed great threats for the health of the residents in China. The treatments for chronic diseases usually endure a long time. Therefore, a lot of medical resources are occupied. In this article, we introduce the chronic diseases management system (CDMS) based on eHealth concept. Patients can detect the index relevant to the chronic diseases by themselves and get some instructive guides about health-care from this system. The application of this management system will enhance the patients' awareness of diseases and thereby lower the expenses of the treatments for chronic diseases.**

Keywords-chronic disease; PHR; eHealth.

I. INTRODUCTION

The incidences of chronic diseases are increasing with the improving of living standard and the changing of eating habit. Chronic diseases occur in young age gradually. In China, chronic diseases have been the main causes of death. As the statistics of the year 2000 showed that 80.9% of mortality was attributed to chronic diseases [1]. Furthermore, chronic diseases will greatly affect the life quality of the aged. Take Shanghai, for example, 73.76% residents developed chronic diseases among the aged in 2008.

Chronic disease, usually, has a long course and is hard to be cured. The interventions and treatments for the patients are important. The Internet of Things (IoT) is a concept that describes how the Internet is being used to link consumer devices and physical assets so that these new endpoints can create and receive a data stream. The method based on IoT will realize the purpose of remote monitoring for the susceptible population and patients.

In this paper, we introduce a chronic disease management system (CDMS) based on eHealth. This system can not only monitor the vital signs of the patients through long distance for the benefit of telemedicine, but also help to arouse the awareness of the health statues for the patients. Compared to the traditional telemedicine systems, the CDMS is more focused on attracting the patients to participate in self-health management. Due to the use of a service component architecture technology, components of the system can run independently to provide web services. The components do not interference each other which makes it convenient for function expansion.

In Section II, we give a brief architecture overview of the CDMS. More details of the CDMS's components are described in Section III to Section VII. Two main features, Front-end Data Cleaning and User-friendly System, are introduced in Section VIII. An example of using the CDMS is given in Section IX. Finally, we drew a conclusion in Section X.

II. CDMS'S ARCHITECTURE

There are always new chronic diseases will be found, and chronic diseases prevention and control methods may change over time. We cannot design a common mode to manage all of the chronic diseases. In order to overcome the uncertainty, the chronic diseases management system (CDMS) should be flexible enough to change the chronic diseases prevention and control methods and scalable enough to manage the new chronic diseases.

The CDMS took SOA (Service-Oriented Architecture) as the main architecture to ensure the system's flexibility and scalability. A Service-Oriented Architecture (SOA) [2] is a set of principles and methodologies for designing and developing software in the form of interoperable services, and the services are unassociated, loosely coupled units of functionality. By SOA, the CDMS can easily add new services to manage new chronic diseases and replace old services to change chronic diseases prevention and control methods.

The system architecture is shown in Figure 1. All components in the system communicate with each other by web service (WS), so each component can evolve respectively according to the different needs and will not affect each other. The components on the upper part of the picture are system-specific components and need to be developed. The others on the lower half are common components, which have the corresponding software implementations.

The system-specific components include the five components of Personal Health Records (PHR), Drug Database, Evidence-based Medicine, Chronic Disease Management Service, Vital Signs Integration Service; we will introduce them in later sections, respectively. Chronic Disease Management Portal is the portal of the CDMS and users can access all components through it.

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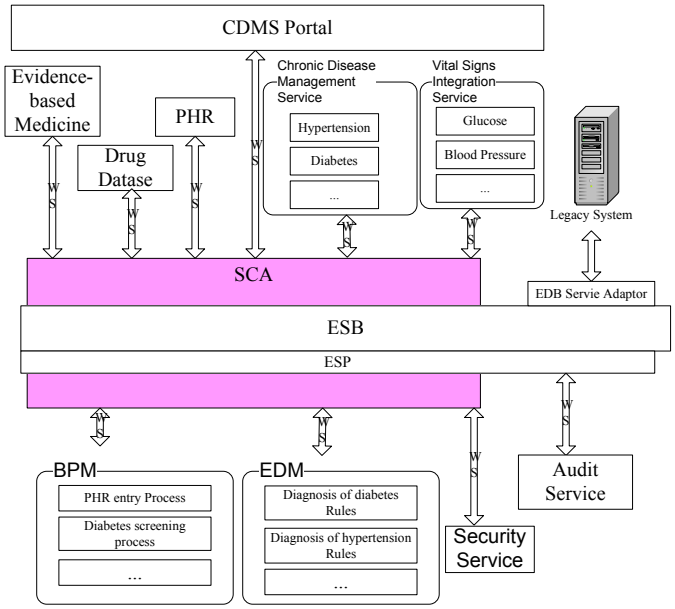

Figure 1. CDMS's architecture

The common components include Enterprise Service Bus (ESB), Event Stream Processing (ESP), Service Component Architecture (SCA), Business Process Management (BPM), Enterprise Decision Management (EDM), and each of the five components has corresponding open source implementations. The CDMS just selects and integrates the implementations by SOA.

ESB, ESP and SCA are the basis of the CDMS. ESB can be used to integrate legacy services or applications (such as HIS, PACS, etc.). By using ESB, the CDMS does not need to repeat patient data entry, which had existed in the legacy systems. ESP enables the CDMS to monitor multiple streams of event data, and analyze them. Normally, ESB is used to audit the accounts in the CDMS. Services are core to SOA. Using SCA, you can build units of functionality, or components, supporting a variety of languages, and then expose them as services over protocols. Moreover, these components can be wired together internally to form higher-level services, or composites. And the services can run in a distributed fashion and be managed as a virtual cloud. By SCA, the CDMS can add more services to manage new chronic diseases easily.

BPM and EDM are used to design visually chronic disease management processes and medical decision-making that can be used to the CDMS immediately. Because visual designers are provided by BPM and EDM, doctors can also design the processes and decision-makings easily. In this way, the CDMS can attract the doctors to participate the design of the system.

III. PERSONAL HEALTH RECORDS (PHR)

Chronic diseases are diseases of long duration and generally slow progression. The prevention and treatment of chronic diseases relies mainly on the patients' own efforts, including developing good living and eating habits, taking medicine on time, etc. In order to store all of the patient-centered data, the CDMS use PHR as the underlying data model.

A personal health record is a collection of health-related information that is documented and maintained by the individual it pertains to. By using PHR, the CDMS allows patients to participate in their own healthcare management by viewing, editing, or discussing their own medical data.

Internationally, several institutions and organizations are concerned with standardization of EHR (Electronic Health Records) [3][4], and some of the standards such as openEHR [5], HL7 CDA [6], CEN 13606 can be used to build the PHR. Compared with other standards, the openEHR is more generic, particularly due to being archetype-driven, and can satisfies many requirements outside the original concept of the "clinical EHR". After our research, we believe that openEHR is best suited to build the PHR model in the CDMS.

But, openEHR only given the definition of the basic structure of PHR, and you need to define the PHR items on your own. In 2009, Ministry of Health of the People's Republic of China published the basic framework and data standard of the health records (China HR) [7]. The standard has defined the minimum collection of health record data items. Therefore，by combining the standard with openEHR, we can define the PHR which is applicable to China.

The openEHR EHR is structured according to a relatively simple model. A central HER object identified by an EHR id specifies references to a number of types of structured, versioned information [5]. According to the definition of the EHR object, compositions are the containers of all clinical and administrative content of the record. In one HER there are two general categories of compositions: event compositions, and longitudinal, or persistent compositions. To add China HR data items into the compositions, we should divide the items into instantaneous information (corresponding to the EVENT composition) and long-term information (corresponding to the PERSITION composition). The items about basic personal information are different from others and are separated as a special component.

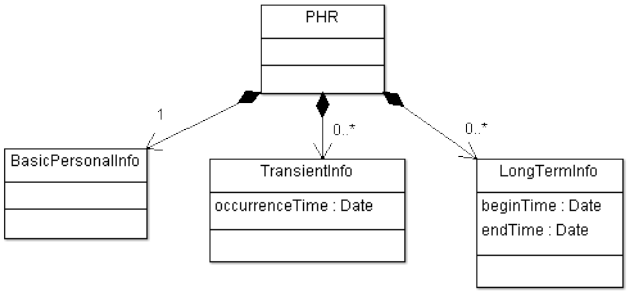

Figure 2. PHR basic structure

The basic structure of the PHR in the CDMS is shown in Figure 2. The PHR object is the root object, which contains all health information of a patient. The BasicPersonalInfo object records the patient's basic information, for example, name, age,

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gender etc. The TransientInfo object is used to record instantaneous information like clinical testing. The LongTermInfo is used to record long-term information like medication records.

IV. DRUG DATABASE

Drug database plays an important role in chronic disease management. All the precise information of a drug is included in this database. The application of this database is to give patients some advices on rational drug use according to their drug use history.

The Drug database component is more general than the other components of the CDMS. In addition to information of drugs for chronic, the component also includes other drugs' information. In the future, the component will be extracted as an independent service application.

We selected more than 2000 drugs and structuralized their information. As the displaying mode is based on web service, we can add more information (such as drug target, drug interaction) into the database later on. We aim to serve for the personalized medicine.

V. VITAL SIGNS INTEGRATION SERVICE (VSIS)

In the CDMS, timely access to the signs information of high-risk groups or patients is of great help for chronic disease prevention and control.

With the development of the Internet of Things technology, through wireless transmission technology, to achieve real-time remote vital signs collection, has become possible and inexpensive.

The schematic diagram of the vital signs integration in the CDMS shows in Figure 3.

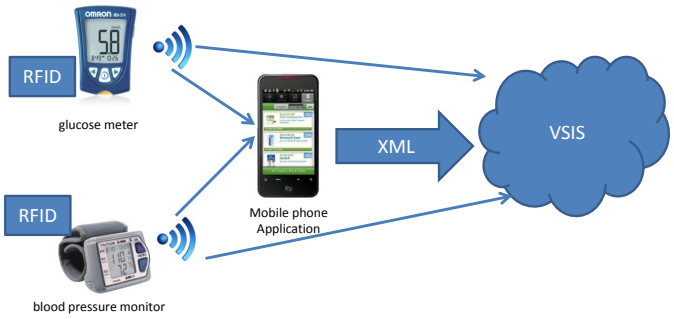

Figure 3. Vital signs integration schematic

All sensors (such as blood pressure monitors, glucose meters) in the figure contain RFID reader devices and wireless transmission module. RFID reader devices are used to identify users. The wireless transmission module is used for data transmission, including two ways of transmission: one way transmits data via Bluetooth to mobile phone, then transmits data to a back-end server; the other way transmits data directly to the servers via GPRS.

The mobile phone application is the core of the entire integration module for signs sensor, it can pre-process the data transmitted by the sensor, also allow users to view the data. At the same time, when the server side have done further analysis of the data, the application can be used to receive the analysis results.

The VSIS provides RESTful WS (the Web Service by Representational State Transfer) to collect data from mobile phones. The transmission between it and the cell phone uses XML as a data interchange format. It does not compel to limit the sensor must be output in XML data format because of the diversity of sensors. If the data generated by the sensors is not XML format, it will be converted through the Enterprise Service Bus configured on a particular service adapter, and then transmitted to the VSIS.

VI. EVIDENCE-BASED MEDICINE

Evidence-based medicine (EBM) aims to apply the best available evidence gained from the scientific method to clinical decision making. It seeks to assess the strength of the evidence of risks and benefits of treatments (including lack of treatment) and diagnostic tests. This helps clinicians understand whether or not a treatment will do more good than harm.

Some useful and helpful evidence-based medicine databases (such as Cochrane, MD Consult) have been widely used through the world. We utilize this idea in our database designing.

Take Hypertension, for instance. We collected some strong evidences from massive publications and integrated them into our system. When a patient refers to the suggestion about "eating habit", the system will come up with the latest evidences on "how to eat healthily as a hypertension patient". We help the patients to manage their health condition and educate themselves about the knowledge of disease.

VII. CHRONIC DISEASE MANAGEMENT SERVICE

Chronic disease management service component is used to manage all chronic diseases. Because every chronic disease haves different day-to-day management process, it is need to develop different sub component. Although different chronic disease needs to develop different sub component, other components of the CDMS that all chronic disease management service's sub components need to call are the same. The disease-related vital signs are provided by the VSIS component, the data used for clinics analysis is provided by the PHR component, the recommended or warning information about patients taking medicines is from the drug database component and some of the latest chronic disease educational information is provided by the evidence-based medicine component.

In order to ensure the flexibility of the system, the management processes in chronic disease management service are provided by the BPM component. Its advantage is that, if you need to make changes to certain chronic disease management process, you can just change the related management processes in the BPM component. And the chronic disease management service component uses rules of the EDM component to diagnose and treat chronic diseases. The EDM component allows doctors to design the rules by themselves.

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VIII. SYSTEM FEATURES

The CDMS is designed to help the patients with chronic diseases to participate in self-health management, and improve their health status while reducing hospitalization.

To achieve this goal, the CDMS should encourage patients to detect vital signs themselves. However, this will lead to more erroneous data are submitted into the CDMS. To overcome the problem, a data-cleaning framework named Front-end Data Cleaning is introduced.

Meanwhile, in order to attract patients to use the system, The CDMS should be user-friendly, which means that the system should be easy to access, the contents provided by the system should be easy to understand.

The two main features will be introduced in this chapter.

A. Front-end Data Cleaning

The VSIS module is normally used to collect patients' own detected vital signs. The biggest problem in the module is to ensure the accuracy of the data submitted by patients. To solve the problem, a simple framework for data cleaning is designed. The framework includes two parts. The first part is a filter to check abnormal data outside the confidence interval and alert the user. If the user confirms the accuracy of the data, the data can be stored in the system and be used to amend the confidence interval. The second part is a calculation module that calculates the confidence interval by the patient's historical data (including the data submitted by the filter). The filter locates in the mobile phone or the sensor, and the calculation module is embedded in the VSIS.

Using the framework, the CDMS can filter a lot of erroneous data in front-end devices. Of course, different vital signs require different algorithms to calculate confidence intervals.

B. User-friendly System

The CDMS Portal lets users to access the CDMS through web browsers. Meanwhile users can also access the CDMS by mobile phone. The VSIS module uses a mobile phone application to collect patients' vital signs. In fact, the application also allows users to access the CDMS. The application can synchronize data with the CDMS while it is online and analysis data offline. In this way users can access the CDMS anywhere anytime.

To let users more easily understood expertise of chronic diseases, the CDMS should promptly adjust the contents in the CDMS by users' feedback. This means the CDMS should be easier to be modified and extended than other traditional medical information systems. Thanks to the SOA technology, the CDSM can meet this demand easily.

IX. EXAMPLE-- MANAGEMENT OF HYPERTENSION

So far, a hypertension management module has been implemented in the CDMS. In this chapter, we will look at how users use the CDMS to manage their hypertension.

When a patient gets a blood pressure monitor and registers for an account, he can use the CDMS. First of all, he should enter his basic information, such as age, gender, blood pressure value, medication information, etc.

Now, he can get the system's help to manage his hypertension. Usually the system will remind him to measure blood pressure and take medicines regularly. When the system detects the abnormal blood pressure values, it will alert him. If this situation continues for several days, the system will notify the doctor to contact him.

X. CONCLUSION

This article describes the design of SOA-based architecture chronic disease management system, the infrastructure of the system using existing SOA technology, and on this basis, develops a service component in the management of chronic disease. Various components interact through web service, evolve independently and will not affect each other. The VSIS component makes full use of existing Internet of Things technology, having the function of remote collection of the user's vital signs, allowing users to keep abreast of their own health, also providing support for the remote diagnosis and treatment from doctors. In order to allow users to get the latest medical research, we developed the component of evidence-based medicine to provide intelligible results of the latest evidence-based medicine. And other components are developed on the purpose of providing effective services to the patients having chronic disease.

However, the current chronic disease management system still has many aspects to be perfected. In PHR component, data structure has not yet fully established, the next work will further improve in this area. In EDM component, we are still unable to provide a language that doctors can directly use to design diagnosis and treatment rules. In the future, we will combine the expertise of medical personnel to create a language in related field, facilitating the use of medical workers.

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