國立交通大學

資訊科學與工程研究所

碩 士 論 文

中介軟體技術應用於台灣線上疫苗接種服務

Middleware-Based On-Line Vaccination Services in Taiwan

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ABSTRACT

Immunization is one of the best ways to protect people and the community against infectious disease. For the growing population, information about people like household registry, medical record and also vaccination record are increasing in a great amount. Storing vaccination record in digital format and using a well management system will help the administration and then eliminate the infectious diseases.

In this thesis, we first survey the current immunization information system, NIIS, in Taiwan and then propose middleware-based system architecture, which provides on-line vaccination services that can improve the management and accessibility of personal vaccination records. We design a central system in the proposed architecture and use a kind of middleware technology, Web Services, which is suitable for integrating heterogeneous platforms, to integrate the different legacy systems used in medical institutions and health agencies with the central system.

Acknowledgement

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Table of Contents

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Preface

Disease prevention is the key to public health, especially for diseases that will infect among people. Immunization is one of the best ways to protect people and the community against infectious disease. By simulating the body's natural resistance to disease, vaccines are used to prevent disease in the people who receive them and protect those who come into contact with unvaccinated individuals suffering infectious diseases.

Now in Taiwan, based on the immunization program, everyone has to take vaccinations from the day his was born. The vaccination record of each person is kept in three places: at his home on a yellow card kept by their parents, in medical institutions where the vaccines are injected, and Health Bureau in his Registered Residence. The importance of vaccination records lies on that they are the bases to determine whether a person had taken some vaccine or not, and the health administration agency converges the records to know the immunization circumstances of each district in Taiwan. Without vaccination records, people will not know when to go to get which vaccine injected, consequently the immunity of them against infectious will not be guaranteed.

With the increment of population, the amount of vaccination data became huge, and hence there is the strategy of building e-government which is aimed at facilitating routine works of each government department. As a result, vaccination records are now kept in digital format, hence there should be a well designed computer system to manage the data.

1.2 Motive and Objective

The immunization information system used now in Taiwan is put online just three years ago. The usability and capability of the system can still be improved. In addition, the information system in hospitals and clinics are not integrated for information exchanging.

The goal of the thesis is to design a new system which should be nationwide, secure and accessible from all the hospital, clinics and health agencies under the government. We will use

middleware technologies to enhance the vaccination service and offer a more adequate and easy solution of keeping and accessing vaccination records for health institutions and the general public.

1.3 Thesis Organization

The thesis divides into 6 chapters. In chapter 2, as the background, we describe the health administration organization, vaccination program and vaccination system in Taiwan. Chapter 3 is a survey of NIIS (National Immunization Information System), the system which is now used nationwide by health agencies in Taiwan. We give a requirement analysis and overview of technologies used in our design in chapter 4. In chapter 5, which is the main portion of this thesis, the architecture of our design is described in details and particular. The last chapter contains the conclusion and future works.

Chapter 2 Background

2.1 Health Administration Organization in Taiwan

As shown in figure 1, the health administration organization is divided into two levels - the central level and local level. At the central level, the Executive Yuan's Department of Health (DOH) is the nation's highest health administration agency, in charge of the administration of health matters nationwide and the guidance, supervision and coordination of local (county, city) health bureaus. At the local level, health bureaus, operated by the 23 county and city governments and special municipalities of Taipei and Kaohsiung, in charge of advancing health and medical operations under their respective jurisdiction. Each health bureau also runs public health centers in urban/rural townships and health offices in remote areas. There are 25 health bureaus and 371 public health centers in Taiwan area in total. Under the DOH, Centers for Disease Control (CDC) is the administrative unit responsible to prevent the communicable diseases from being widespread in the whole county, so planning and promoting of immunization in Taiwan are the key missions of CDC.

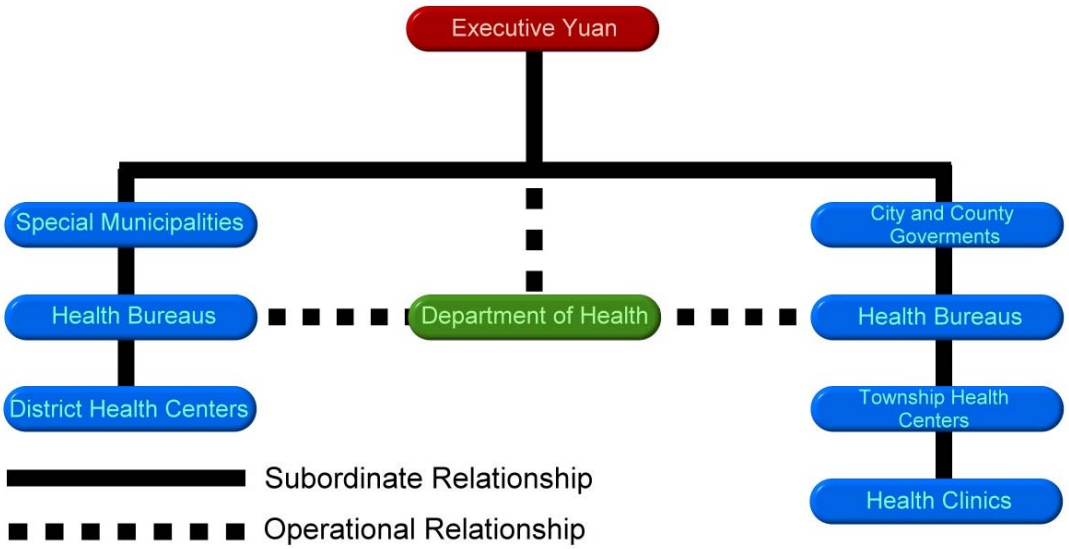


Figure 1 *Current Health Administration System [1]*

2.2 Present Vaccination Program in Taiwan

Table 1 is the immunization schedule in Taiwan, and the free routine vaccine provided to children and the applied year of each routine vaccine is shown in table 2. The routine vaccinations protect the majority of children against the respective diseases and prevent them infecting others. This will also protect the children who have not been vaccinated, e.g. newborns or children who cannot be inoculated for some reason. To maintain effective protection, these vaccinations have to continue even when a disease is no longer prevalent in our country for at least as long as the disease remains elsewhere in the world. Otherwise the number of people susceptible will rise and the disease may gain a foothold once more. This means that everyone has to be vaccinated for their own protection.

Table 1 *Current Immunization Schedule in Taiwan (partial)*

General section						
Age	Hepatitis B Globulin	BCG (Tubercu-losis)	Hepatitis B	Diphtheria Tetanus Pertussis	Polio	responsible for vaccination
< 24 hrs	I					Health Bureau
> 24 hrs		I				
3-5 days			I			
1 mth			II			
2 mths				I	I	
4 mths				II	II	
6 mths			III	III	III	
	Measles	Japanese Encephalitis	Mumps Rubella			
9 mths	I					
15 mths		I*	I			

* Second dose after 2 weeks

Source: *Centers for Disease Control, R.O.C*

Table 2 *Free Routine Vaccines for Children*

Vaccine	DTP	BCG	JE	OPV	HepB	MMR	Varicella
Applied Year	1955	1965	1968	1983	1986	1992	2004

Source: *Centers for Disease Control, R.O.C.*

Besides the routine vaccines, there are also vaccines that people can get at their own expanse, e.g. yellow fever, rabies, hepatitis A, and influenza. However, in some situations, these vaccines may be free. For example, during the flu season every year, elder aged over 65 years and children aged between 6 months and 2 years can get vaccination for free. Moreover, they provide young children aged 2 and older in 39 towns of 12 counties/cities (including 30 mountain regions and 9 areas that are near by the mountain regions) with free hepatitis A vaccination because the people live in these areas do not have enough hygienic knowlage and habits. In addition, the mini-Three Links with China, which have greatly increased personal contacts and commercial exchanges between the two sides of the Taiwan Strait, might lead to the importation of hepatitis A virus from China and threaten the health of children in Taiwan. Therefore, free hepatitis A vaccination is being carried out for children aged 2 and older in Chinmen and Matsu regions.

2.3 Evolution of Vaccination Information System in Taiwan

In the immunization operation in Taiwan, since 1983, personal vaccination data has been recorded manually on the vaccination card (so called yellow card, figure 2), which was delivered to newborn baby's parents, by the contracted medical institutions that did the vaccination. And then the parents passed on the vaccination card of their bay to the clerks of local health centers who put all information together and put down the record to personal immunization file kept by the local health bureaus. It was a time-consuming process and data were updated very slowly, and also data inconsistency was likely to occur. In the meantime, as the lacking of a central management database, it was quite difficult to transmit and receive information, so that people in change had to rely on paper work to exchange information.

預防接種時程及紀錄表

姓名：＿＿＿＿＿＿　身分證號碼：

出生日期：民國＿＿年＿＿月＿＿日　性別：＿＿＿

聯絡住址：＿＿＿＿＿＿＿＿＿＿　電話：＿＿＿＿＿

戶籍地址：＿＿＿＿＿＿＿＿＿＿　電話：＿＿＿＿＿

母親姓名：＿＿＿＿＿＿　身分證號碼：

適合接種年齡	疫苗種類		預約日期	接種日期	接種單位
出生後儘速接種(不超過24小時)	B型肝炎免疫球蛋白	一劑			
出生24小時以後	卡介苗	一劑			
出生滿2~5天	B型肝炎疫苗	第一劑			
出生滿1個月	B型肝炎疫苗	第二劑			
出生滿2個月	白喉破傷風百日咳混合疫苗	第一劑			
	小兒麻痺口服疫苗	第一劑			
出生滿4個月	白喉破傷風百日咳混合疫苗	第二劑			
	小兒麻痺口服疫苗	第二劑			
出生滿6個月	B型肝炎疫苗	第三劑			
	白喉破傷風百日咳混合疫苗	第三劑			
	小兒麻痺口服疫苗	第三劑			

※ 表列為目前由政府提供之常規預防接種項目
※ 本接種紀錄請家長務必永久保存，以備國小新生入學、出國留學及各項健康紀錄檢查之需

預防接種時程及紀錄表（續）

適合接種年齡	疫苗種類		預約日期	接種日期	接種單位
出生滿12個月	水痘疫苗	一劑			
出生滿12~15個月	麻疹腮腺炎德國麻疹混合疫苗	第一劑			
出生滿1年3個月	日本腦炎疫苗(每年集中於3月至5月接種)	第一劑			
	日本腦炎疫苗(每年集中於3月至5月接種)	隔二週第二劑			
出生滿1年6個月	白喉破傷風百日咳混合疫苗	第四劑			
	小兒麻痺口服疫苗	第四劑			
出生滿2年3個月	日本腦炎疫苗(每年集中於3月至5月接種)	第三劑			
國小1年級	破傷風減量白喉混合疫苗	一劑			
	小兒麻痺口服疫苗	第五劑			
	麻疹腮腺炎德國麻疹混合疫苗	第二劑			
	日本腦炎疫苗(每年集中於3月至5月接種)	第四劑			
	卡介苗疤痕普查(無疤且測驗陰性者補種)				

Figure 2 *Yellow Card*

The immunization services of health centers have been valued increasingly, so they attempted to the use of computers to increase their efficiency. The immunization data were to be kept in digital format and managed by a computer information system. The DOH began to push computerization for the health departments in 1993 and have established DOS PHIS (depicted in Figure 3) to help health departments and centers to establish three major systems-outpatient service, immunization for health protection, and administrative management. However, the new operations needed for immunization services increased continually, and the information technology and network environment were also changing rapidly. As a result, the DOS PHIS has become inadequate with time.

People can get immunization at any health agency which provides the vaccines as their convenience. Under PHIS, when a man goes to a medical institution (including health centers) to receive vaccination, he must complete a basic personal file and the doctor will enter the vaccination and other information into a referral slip and into the medical record. If the man goes to the health center located of his domicile to get vaccination, the information about him

can immediately be entered into the DOS PHIS system. On the contrary, if he goes to get vaccination in a health center or another medical institution not located at his domicile, he needs to complete a yellow clip and mail it to the health center of his domicile, in which the staffs will key in the information manually for filing and then the health center has to use PHIS to put the data of vaccination in other places into a notice for transmission together with the referral slip to the health department, which will in turn transmit it to the health department of a county or city (the so-called consolidation system), consuming much time and manpower. The extraction of the basic personal data must go through the DOH Information Center, which, in doing so, has to ask the Ministry of the Interior to transmit the information of changes to the regional information center (RC) every two weeks for distribution to health centers. The health centers connect with the domicile registration system in this way to make health staffs on the base level to know the information (birth date, moving out of or moving into the domicile district) for use as the basic materials for administration. Because there is no official specifically in charge of this business and also because the problem arising from line connection with the RC, the domicile department cannot transmit the data of domicile changes within the required two weeks. Therefore, there is often delay in sending the referral slips, sometimes for as long as one or two months.

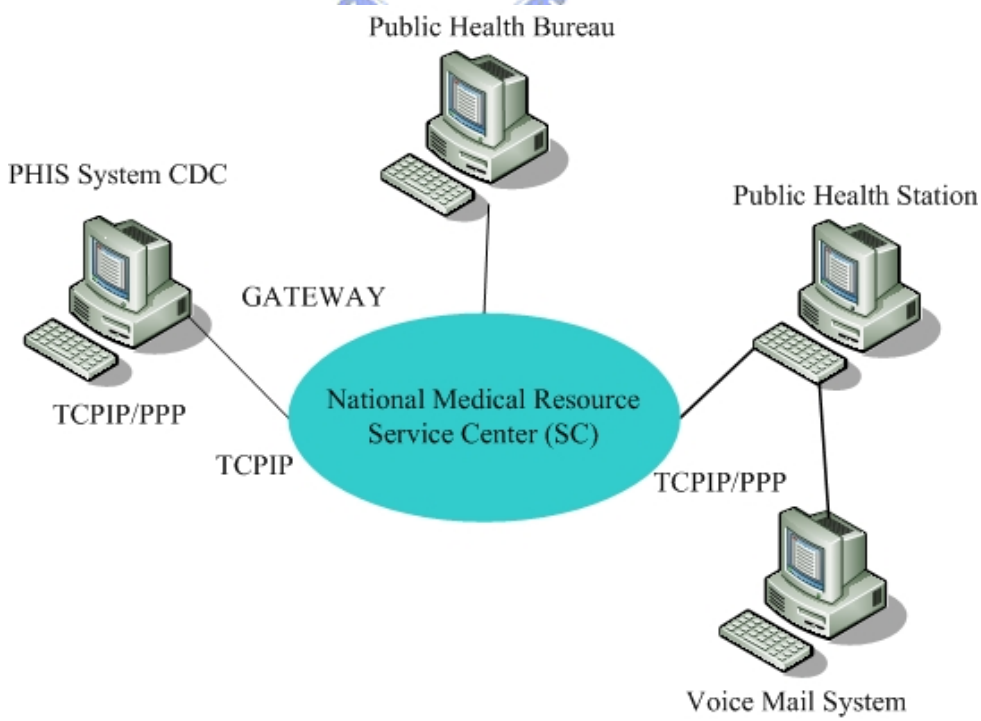


Figure 3 *PHIS Structure [2]*

Taking into consideration of the freedom of movement of people, the convenience for keeping health data, and the fact that immunization is a nationwide demand, Taiwan CDC hopes to use the new information technology to develop and set up a “National Immunization Information System” (a.k.a. NIIS) based on the existent network for health agencies and medical institutions. This system can be used to integrate the current administrative health organizations, the hospitals contracted for administering vaccination and the database of domicile department so that they can take advantage of the system’s function of automatic referral and consolidation to keep the immunization data in whole and reduce the workload of the staff of the health center. The evaluation of immunization information system is arranged in table 3, and in the next chapter, we will go into particulars about NIIS.

Table 3 *Evolution of Immunization Information System in Taiwan*

Year	1993	2001	2002	2003	2004
State	PHIS-DOS Established	Developing PHIS-Windows	Developing NIIS	NIIS Introduced	NIIS Established
System Being Used	PHIS-DOS	PHIS-DOS	PHIS-Windows	NIIS	NIIS

Chapter 3 Survey of NIIS

3.1 Introduction

Commissioned by DOH, NIIS (National Immunization Information System) is designed by Institute for Information Industry Corp., and is developed and built up by Wistron ITS Corp.. NIIS inherits from the immunization subsystem of PHIS (Primary Health Information System), however, not like PHIS, which is a Windows application, NIIS is a web-based system with friendly user interface. As a result, it simplifies the procedures of vaccine works and provides convenience to public.

NIIS has been built up since 2002, and introduced nationwide to the 25 Health Bureaus of counties and provincial municipalities and special municipalities, 374 Health Centers of townships and county municipalities, and 600 Medical Centers.

3.2 System Architecture

The database architecture of NIIS is distributed but also centralized. Each local Health Bureaus has its own database to maintain the vaccination data within its jurisdiction. As the NIIS operation environment depicted in figure 4, work stations in Public Health Centers connect to Internet through ADSL connection, and AP servers in Public Health Bureaus and NIIS server in CDC all connect to Internet through T1 or T3 leased line.

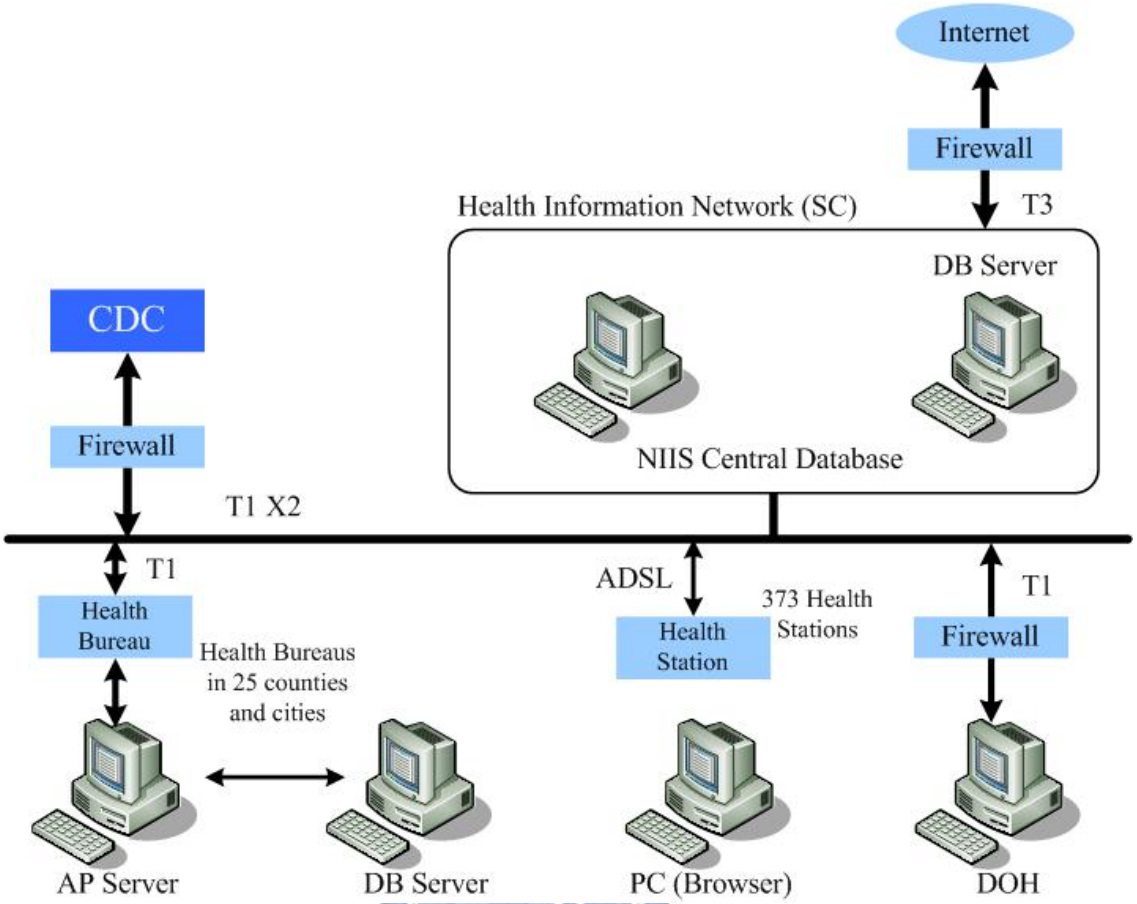


Figure 4 *NIIS Operation Environment [2]*

As the NIIS operation architecture shown in figure 5, work stations in Health Centers connect directly to servers in Health Bureau whose jurisdiction it is in via ADSL, and the servers in Health Bureaus connect to Central Referral Consolidation System Server, which gets basic public information from Household Registration and Conscription Information System of Ministry of the Interior, to exchange referral data. Although the Central Database in CDC is depicted in the figure, but it is not on-line now in practice, i.e. one Health Bureau can not access the data in another Health Bureau.

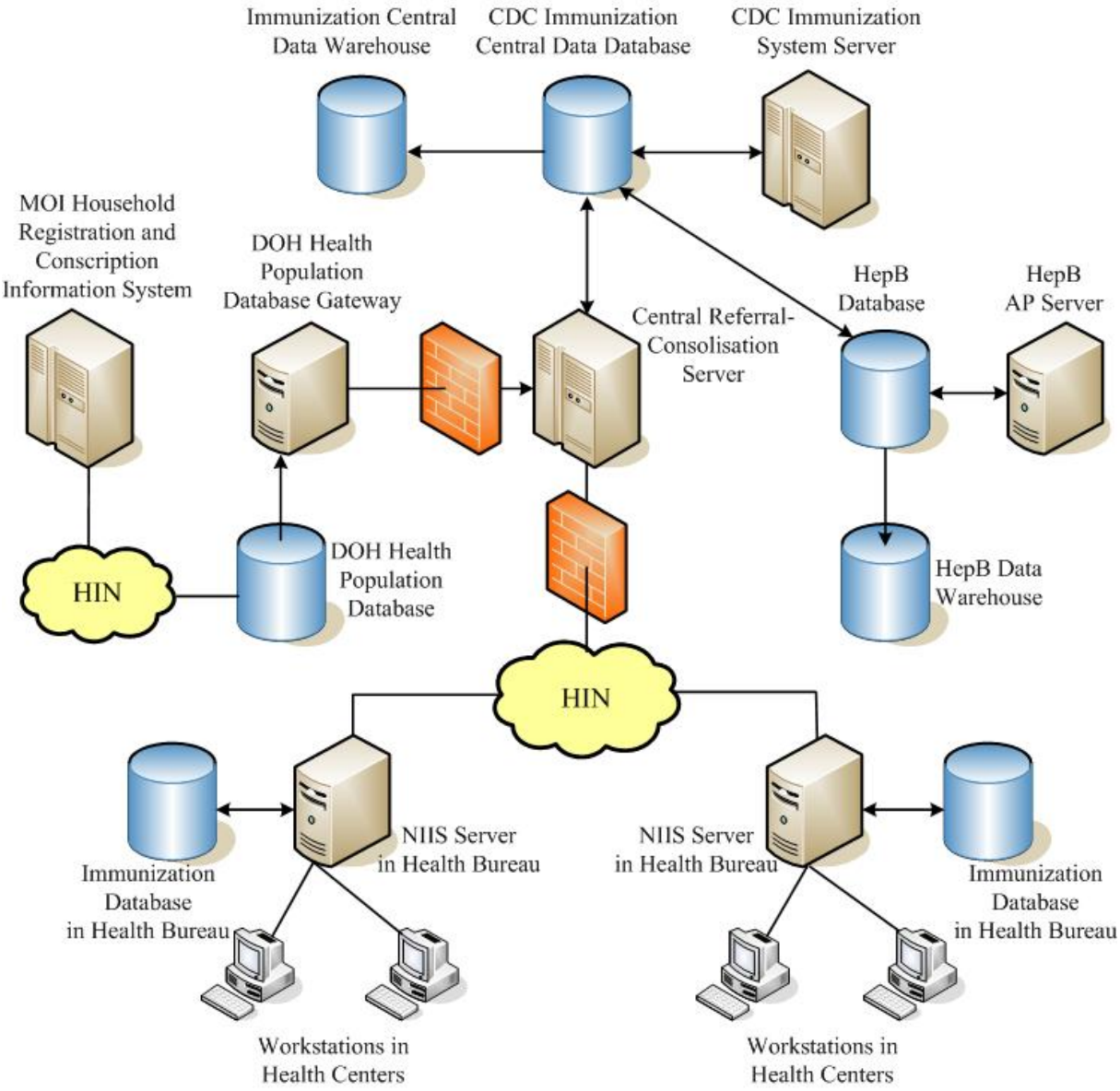


Figure 5 *NIIS Operation Architecture [3]*

3.3 User Interface

NIIS is a Web-based system, and all steps needed in vaccination operation are fulfilled on the web pages. In this way, NIIS provides consistent and friendly use interfaces for staffs on the base level to simplify the procedure of vaccination. Following are some snapshots of the NIIS operations including login page, record page and forms of statistics.

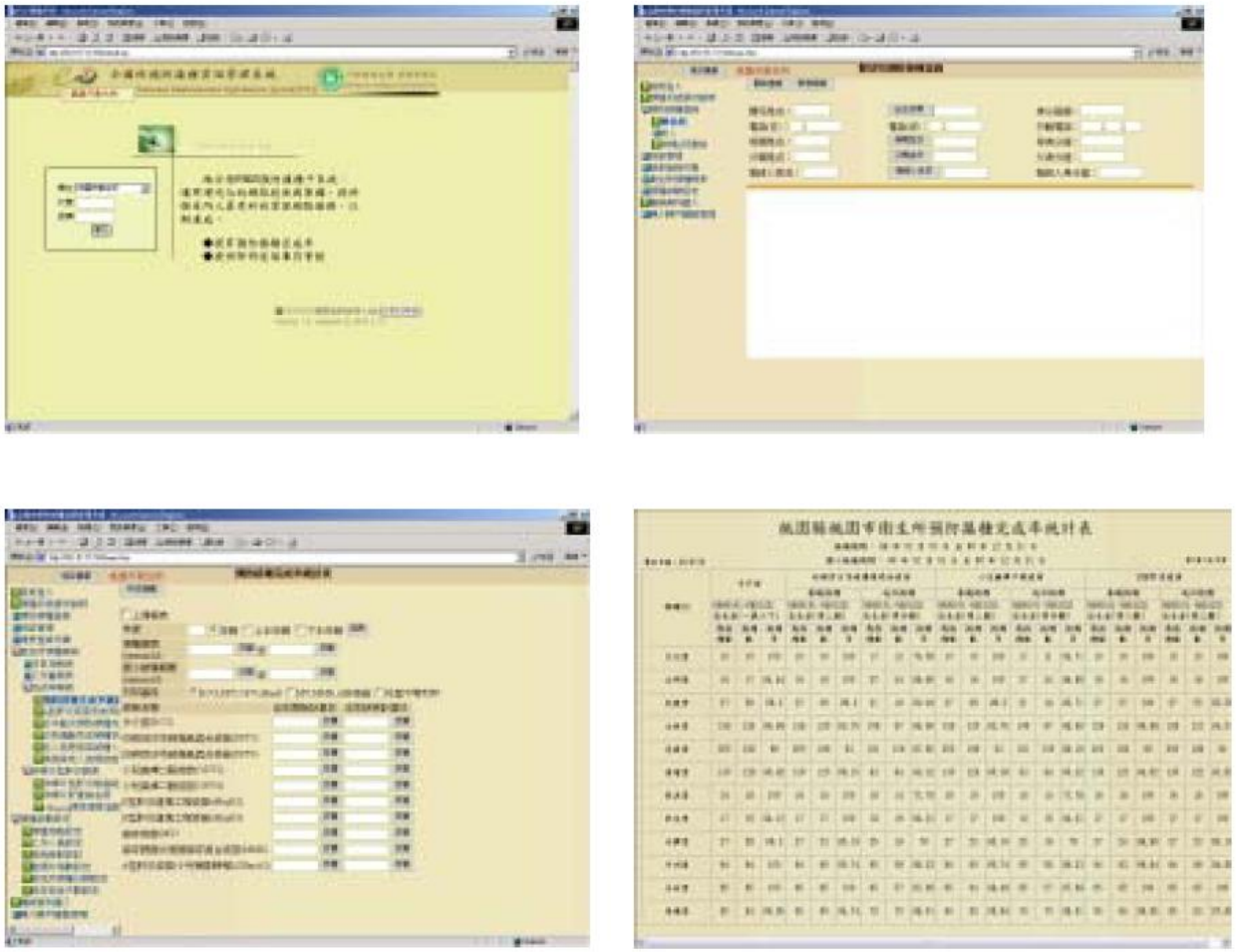


Figure 6 *Snapshots of NIIS Web-based User Interface [4]*

3.4 Database Schema

Taking into consideration of database management, data independency, storage of duplicate data, accessing speed, integration and recovery, the database architecture of NIIS is designed to be distributed but also centralized. And since that the data in local database of health bureau is an accomplished fact, the local data should be fragmented and triplicate to central database, i.e. local health bureaus do not need to replicate all the data to central database, but only need to replicate chosen data according to the demand and policy of the central authority.

After considering the data construction, local database schema and the report sent to central authority by health bureaus, they made up central database schema applied to NIIS. Figure 7 and figure 8 are respectively the data model of local database in health bureaus and of central database in CDC.

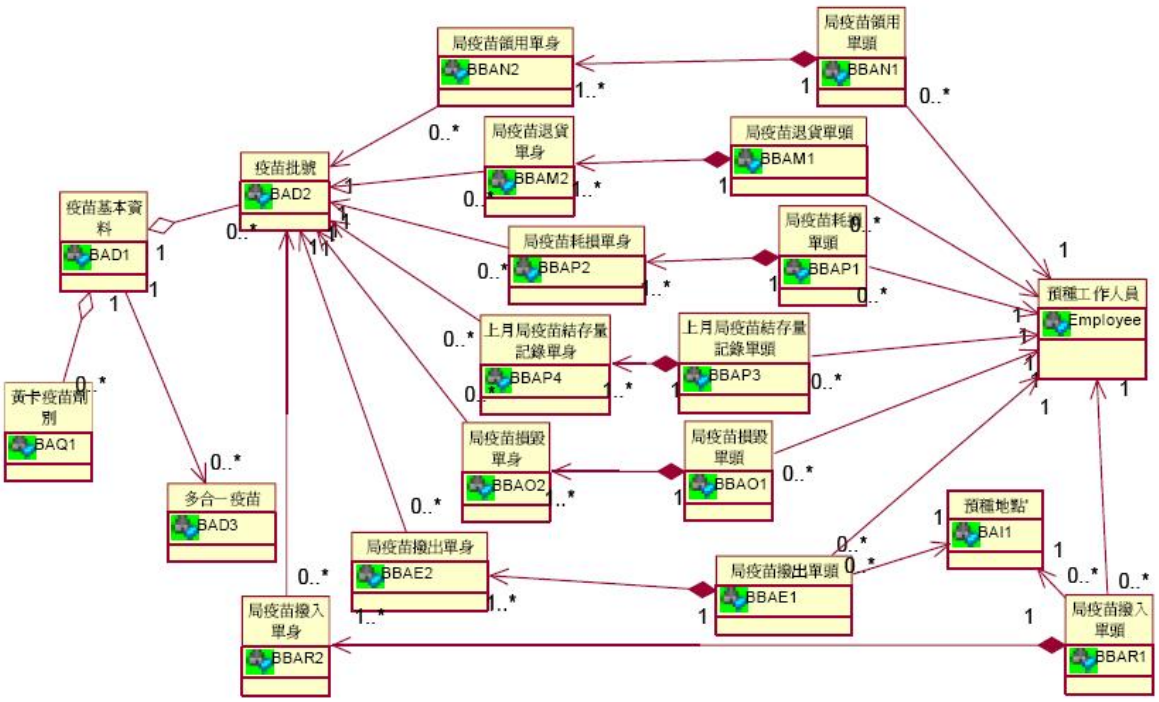


Figure 7 *Data Model of Local Database in Health Bureau [4]*

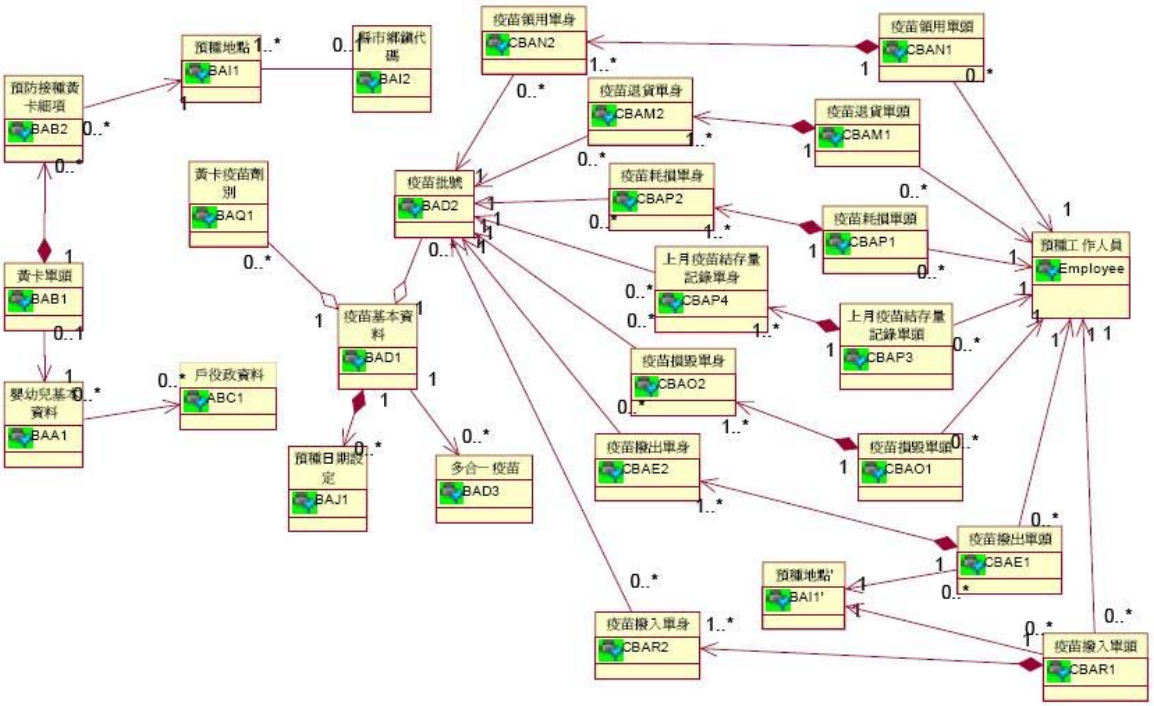


Figure 8 *Data Model of Central Database in CDC [4]*

The main differences between data model of local database and of central database are as follows:

a. Local database schema has tables that store the circumstances of how the contracted medical institutions use the vaccines, e.g. BAF1, BAF2, and BAF3.
b. Local database schema has tables that store the items on yellow card, e.g. BAb1, BAB2.
c. Local database stores the basic household registry data of babies, and the investigation of side effects.
d. Central database stores data about health bureau with tables named begins with an additional letter “B”, like BBAR2, BBAP4, and etc.

3.5 System Operation

The main function of NIIS is referral-consolidation. The referral-consolidation may be needed in two circumstances: someone goes to a medical institution in or outside the area under his jurisdiction of health bureau.

Referral procedures in the area under one's jurisdiction of health bureau:

a. The direct line of health center reaches the database system of health bureau to upgrade the record data.
b. Contract medical institutions export the records into XML format, and then send the files via e-mail or discs to the health center.
c. Traditional referral clips are used for noticing the health centers of counties and cities.

Referral procedures outside the area under one's jurisdiction of health bureau:

a. If inoculation of the vaccine in the contract medical institutions, the vaccination record is transferred to local health center first.
b. Staffs of local health center establish the data and update it to the local database.
c. At 12 every night, health bureau’s system automatically sends the records not belonging to people under its jurisdiction to the central server.
d. The central server will contrast the information with database of Affairs of Household Registration, and transmit the record to the right place.

3.6 Problems

NIIS facilitates the tasks of vaccination in some degree, but there are still several deficiencies or problems we can improve or solve:

a. People still have to keep the yellow card, and if the card is gone, they can not access their vaccination records conveniently.
b. The data belongs to a Health Bureau can not be accessed by another Health Bureau, thus people can only get their vaccination records from health bureau in their domicile.
c. Between Health Centers in the same city, the yellow clip for referral is still used.
d. The systems used by Public Health Centers and by hospitals or clinics are not well integrated.

Chapter 4 Requirement Analysis and Technologies

4.1 Requirement Analysis

4.1.1 Functionality

The system will provide following services:

a. Automation of referral-consolidation.
b. Looking up service for personal vaccination records.
c. Looking up service for information about vaccines of medical institutions.

4.1.2 Operation

The system should be based on exist systems in hospitals, clinic and health bureaus. Furthermore, the system needs Internet access when transferring data to the central database, and through Internet, legacy systems can cooperate and the users can get access to the central system.

4.1.3 Scalability and Capacity

The system should be large-scale to maintain vaccination records for everyone in the country and provide nationwide vaccination services.

4.1.4 Integration

We should use technologies that can integrate heterogeneous and autonomous systems to automate the interoperation between them to simplify the operation related to vaccination.

4.1.5 Security

A unique username and password are required to get access to the system, and for different group of account, they have different limits of authority. Furthermore, all data transfer need to be encrypted, and all communications have to be over a secured connection.

4.2 Related Works

In [5], they define reference architecture for distributed database management systems from system and schema viewpoints and show how various FDBS architectures can be developed and then define a methodology for developing one of the popular architectures of an FDBS. We refer to the bottom-up development process proposed in [5] to design our OVS system.

It is mentioned in [6] that XML (Extensible Markup Language) has become the standard for data and document interchange between distributed systems. [6] focuses particularly on searches through legacy databases and on the changes you can make to your legacy systems to effectively exploit XML. SkyQuery [7] and Autonomous Data Integration Middleware (ADIM) [8] are two researches that use Web Services to design architecture for data distribution and integration in distributed heterogeneous database systems.

SkyQuery is a prototype of an evolving federation of geographically separate astronomy databases on the Internet. It has a web interface that allows astronomers to query spatial data stored in the databases participating in the federation. In particular, SkyQuery evaluates a probabilistic federated spatial join query called the cross match query. The SkyQuery architecture is based on the wrapper mediator architecture, which is common in federated database systems. It consists of three components (1) the Clients, (2) the Portal and (3) the SkyNodes. The Portal is the mediator and the SkyNodes contain the wrappers around databases. These three components coordinate with each other to perform two tasks: allowing databases to join the federation, and evaluating cross match queries. It adopts Web Services as the main communication and encapsulation interface both for the query processor and data sources wrappers.

In ADIM, the data schema integration is achieved by XML based global schema which is used by QPE (Query Execution Processor) and QMP (Query Mapping Processor) in the client and server components to translate and exchange metadata between data sources. The heterogeneity of access interfaces and protocols provided by each distributed paradigm is resolved by adopting Web Service as the communication model for uniformity of communication protocol in HTTP, message exchange in SOAP for service request and response, and service definition and description in WSDL. They also develop the SOAP wrapper generator which can generate Java code to wrap the server API into Web Services

and have implemented a prototype of ADIM in the distributed environment. They are working on the two-phase-commit service and distributed scheduler to extend ADIM to allow database update operations.

About the security issues, it is mentioned in [9] that SSL [17], which operates between the HTTP and TCP network layers, is the most popular tool that provides a secure channel between a client and a Web server. Even though SSL is the de facto standard for transport layer security, its high overhead and poor scalability are two major problems in designing secure large-scale network servers. Therefore, improving the performance of SSL-enabled network servers is critical for designing scalable and high-performance data centers. [10] used the Netscape Enterprise Server and Apache Web server, and it was shown that the session reuse is critical for improving the performance of Web servers. And [9] examined the impact of SSL offering and SSL-session-aware distribution in cluster-based network servers and proposed a back-end forwarding scheme to achieve a good load balance among server nodes.

NICTIZ is the standardization authority for data exchange in healthcare for the Netherlands. [11] discusses the issues, lessons learned and pitfalls in applying web services to a large, complex, real-life environment. The experience of Dr. Marc de Graauw in implementing Web Services for healthcare gives us guidelines when designing our system.

4.3 Web Services

The World Wide Web Consortium provides a definition to Web Services: "A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. [12]"

4.3.1 Core Specifications of Web Services

Web services specifications compose together to provide interoperable protocols for Security, Reliable Messaging, and Transactions in loosely coupled systems. The specifications build on top of the core XML and SOAP standards.

4.3.1.1 XML

The Extensible Markup Language (XML) [13] is a general-purpose markup language. It is classified as an extensible language because it allows its users to define their own tags. Its primary purpose is to facilitate the sharing of data across different information systems, particularly via the Internet

4.3.1.2 SOAP

Simple Object Access Protocol (SOAP) [14] is a protocol for the exchange of information in a decentralized, distributed environment. It is an XML-based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined data types, and a convention for representing remote procedure calls and responses. SOAP can potentially be used in combination with a variety of other protocols like HTTP and SMTP.

4.3.1.3 WSDL

WSDL [15] stands for Web Services Description Language. For our purposes, we can say that a WSDL file is an XML document that describes a set of SOAP messages and how the messages are exchanged. In other words, WSDL is to SOAP what IDL is to CORBA or COM. Since WSDL is XML, it is readable and editable but in most cases, it is generated and consumed by software.

4.3.1.4 UDDI

The Universal Description, Discovery, and Integration (UDDI) [16] specification defines a SOAP-based Web service for locating WSDL-formatted protocol descriptions of Web services. UDDI provides a foundation for developers and administrators to readily share information about internal Web services across the enterprise and public Web services across the Internet

4.3.2 Basic Operation

There are probably as many definitions of XML Web Service as there are companies building them, but almost all definitions have these things in common:

- XML Web Services expose useful functionality to Web users through a standard Web protocol. In most cases, the protocol used is SOAP.
- XML Web services provide a way to describe their interfaces in enough detail to allow a user to build a client application to talk to them. This description is usually provided in an XML document called a WSDL document.
- XML Web services are registered so that potential users can find them easily. This is done with UDDI.

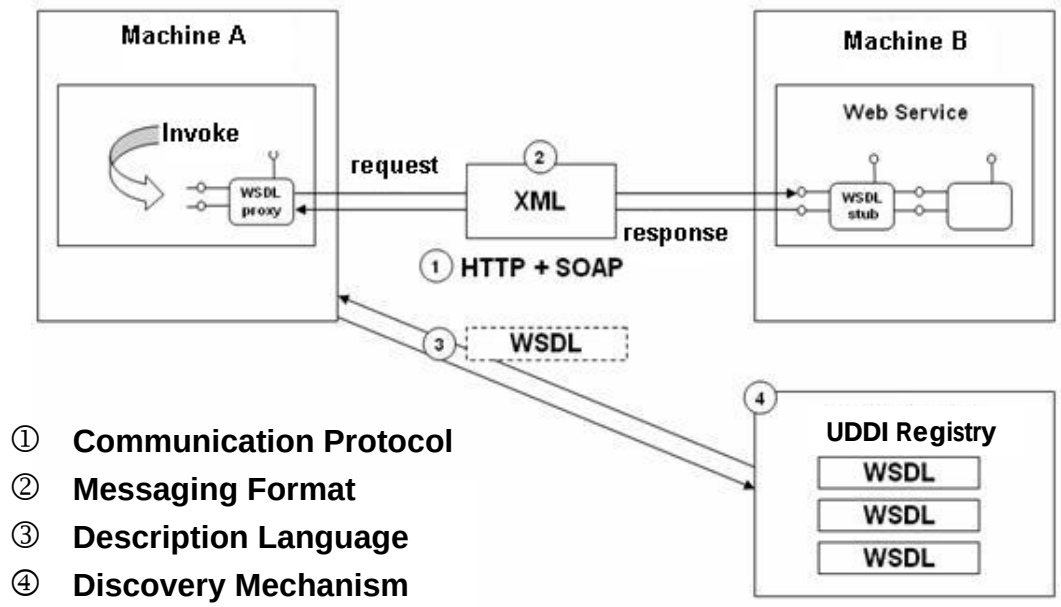


Figure 9 *Standard XML Web Service*

4.4 Secure Socket Layer

4.4.1 Overview

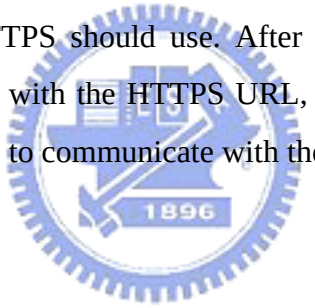
Secure Sockets Layer (SSL) is the most widely used protocol for implementing cryptography over a distributed communication protocol such as HTTP. This is achieved by using symmetric key cryptography for data encryption between the client and server, and asymmetric key cryptography (or public/private key cryptography) to authenticate the identities of communicating parties as well as to encrypt the shared encryption key that is used during establishing SSL session. This means that the data being sent is encrypted by one side – transmitted, then decrypted by the other side before processing. This is a two-way process, meaning that both the server AND the browser encrypt all traffic before sending out data.

Another important aspect of the SSL protocol is Authentication. This means that during the initial attempt to communicate with a web server over a secure connection, that server will present your web browser with a set of credentials, in the form of a "Certificate", as proof the site is who and what it claims to be.

4.4.2 Securing Web Services with SSL

Since that the message exchanged in OVS will not go through intermediates except the central system, and all local systems and the central system are trustworthy, we only need to ensure the security between local system and central system to meet the secure requirement of OVS. Moreover the communication between local and central is using SOAP over HTTP, hence HTTP over is used in OVS system.

To securing Web Services with SSL, we need to apply the required features of SSL on the web servers which the web services run on. First, we have to generate certificates and keystores, and then set a port which HTTPS should use. After that, we have to modify the WSDL description of the Web Service with the HTTPS URL, so that the service consumer can use the accurate protocol of HTTPS to communicate with the web services.



Chapter 5 Design and Integration

According to the requirement analysis in chapter 4, we design a system that integrates the heterogeneous and autonomous systems of hospitals, clinics and heath bureaus to facilitate the tasks about vaccination and provide service for the general public to get their vaccination records online. From here the system will be referred as the OVS system, where OVS is an acronym of On-Line Vaccination Services.

5.1 Overview

Depicted in figure 10, OVS is based on the existing health system environment in Taiwan, and has a central system locating in CDC. The central system has a web and application server providing services and a database server collecting data. Public Health Bureaus and medical institutions and connect to central system through Health Information Network (HIN), and work stations connect to local systems through LAN or Internet. Also, public users can connect to central system to use the services wherever they are.

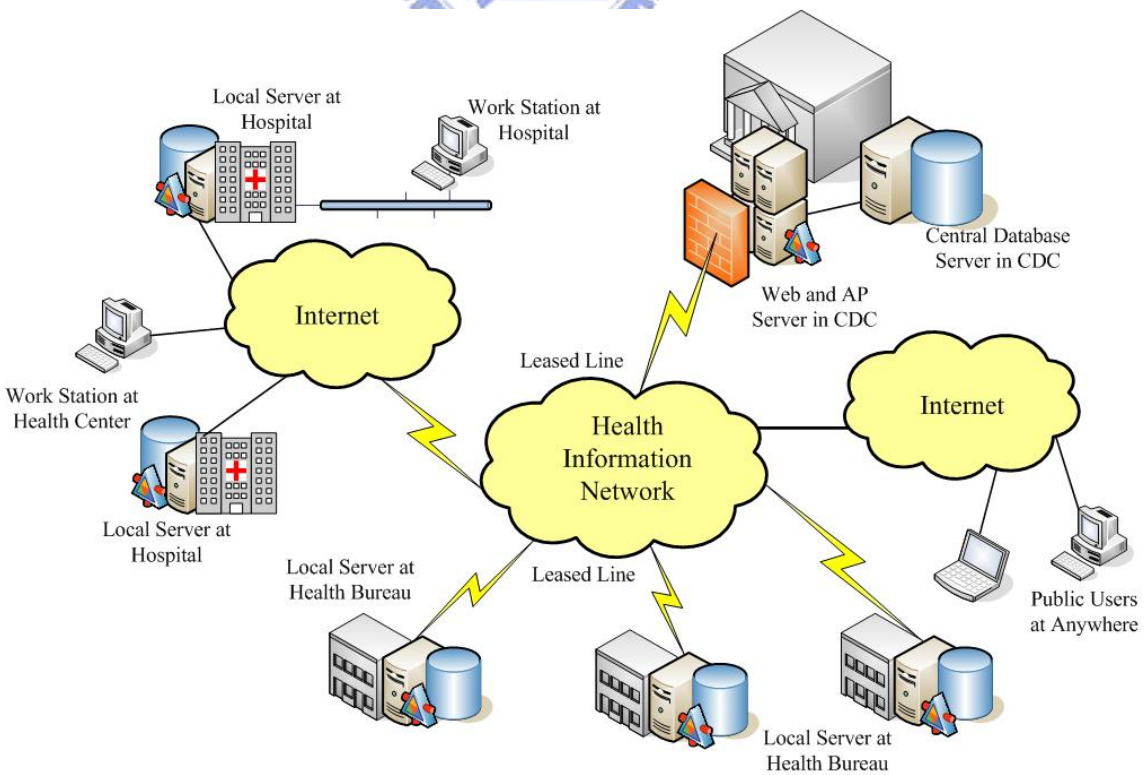


Figure 10 *OVS System Operation Environment*

We apply Web Services to the central system, and also to legacy systems of each hospital, clinic, and health bureau, so that they can communicate with each other no matter what system platform they use. Figure 11 below depicts OVS system architecture: the data transmission is based on Web Services and the control component is in the central system; Vaccination Central Database is used to store vaccination records of everyone in Taiwan; OVS provides web user interfaces for public end user to access the central database.

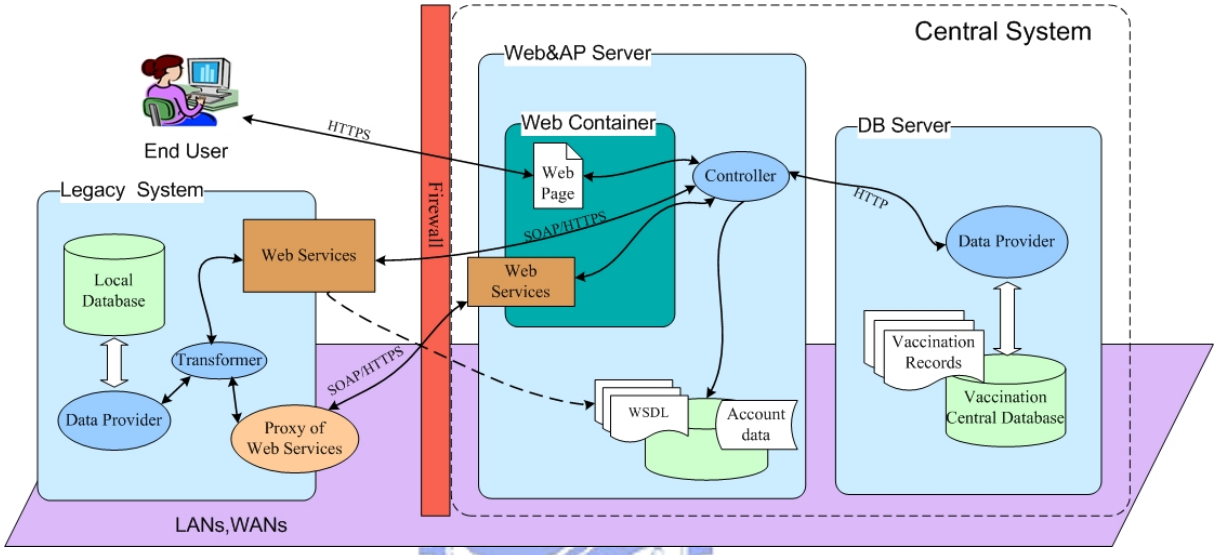


Figure 11 *OVS System Architecture*

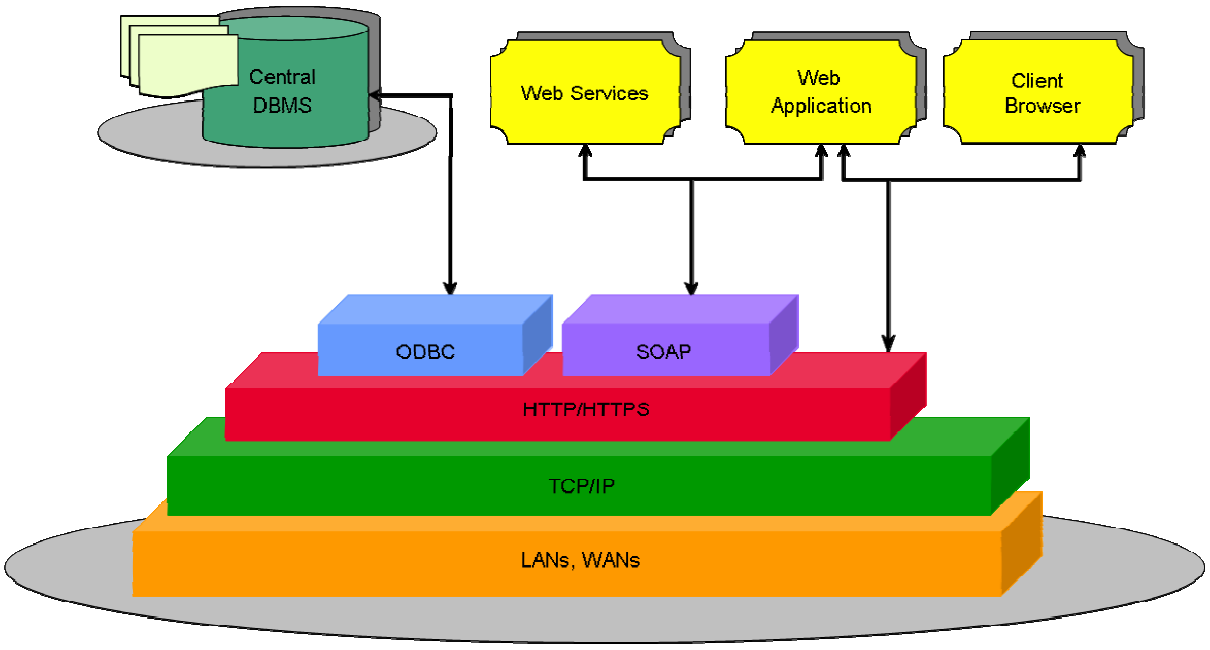


Figure 12 *OVS Protocol Stack*

Figure 12 is protocol stack of OVS that depicts what protocol the connections to the central system use. OVS is running on the top of TCP/IP, with LANs/WANs on the bottom level. Web Application communicates with Local Web Services via SOAP over HTTPS. Client Browser connects to Web Application via HTTPS. ODBC is used to connect to Central DB over HTTP

In functional scope, the OVS system can divide into three portions: data mapping portion, communication and control portion, and central database management portion (depicted in figure 13). The function of each component and how they interoperate to each other will be explained in following sections.

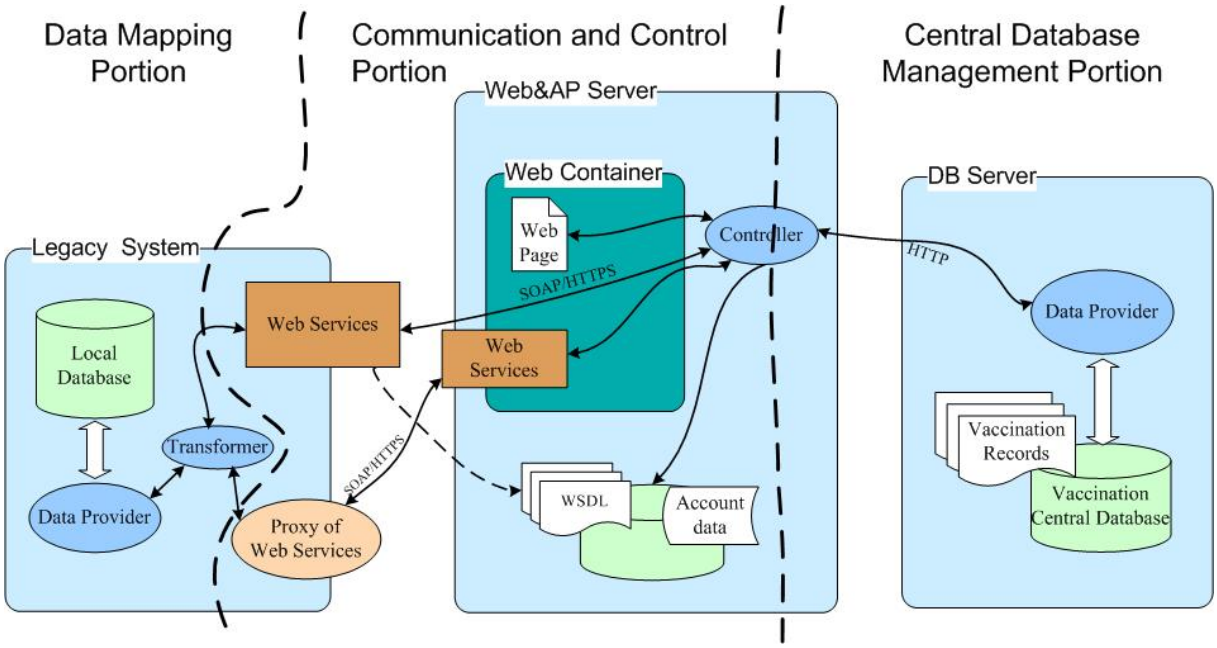


Figure 13 *OVS System Components in Functional Scope*

5.2 Data Mapping

5.2.1 Functions

Because the data model and data format of a local database differ from that of central database, when a local system exchanges data with the central system, a translation of data must be done. The data mapping portion is in the local system and does the translations between local and global schemas. The components of data mapping portion are shown in figure 14.

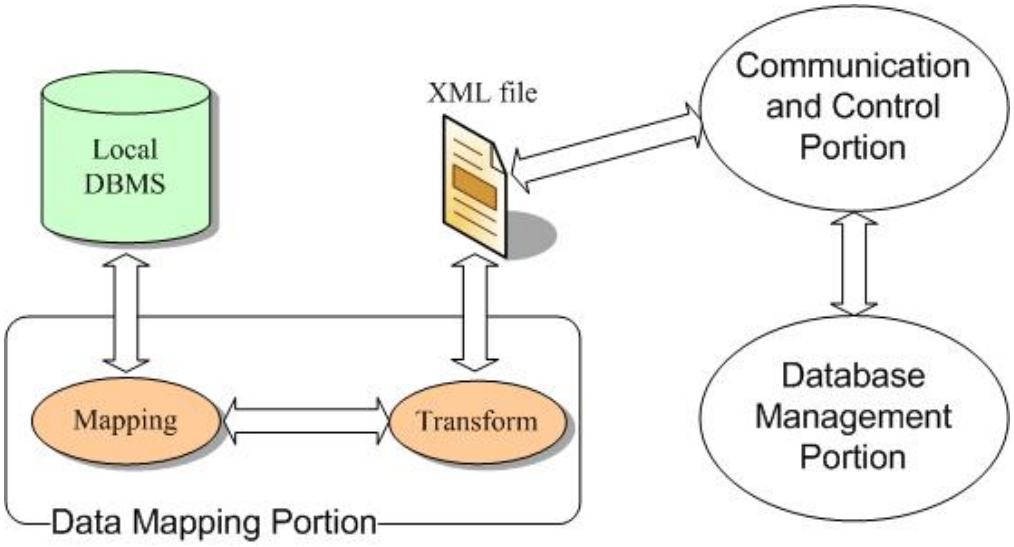


Figure 14 *Components of Data Mapping Portion*

5.2.2 Global Schema

The global schema of OVS system is in XML format. Every personal vaccination record contains an element of people's basic information, which including elements like name, id, date of birth, sex, parents, domicile address and telephone number. There is also information about vaccination in the records. Each vaccine corresponds to an element, in which there are elements of the name of vaccine, scheduled date of vaccination, date of vaccination, location of vaccination, and name of the medical staff that did the vaccination. Figure 15 is an example of designed vaccination record in XML format, and figure 16 is the XML schema of the records.

```
<個人預防接種資料>
  <基本資料>
    <姓名>王小明</姓名>
    <身分證號碼>A123456789</身分證號碼>
    <出生年>2007</出生年>
    <出生月日>01-01</出生月日>
    <性別>男</性別>
    <父母>
      <父親>王爸爸</父親>
      <母親>王媽媽</母親>
    </父母>
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    <電話>02-3456789</電話>
  </基本資料>
  <預防接種紀錄>
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      <接種地點>新竹馬偕醫院</接種地點>
      <施種人員>林護士</施種人員>
    </接種疫苗>
    <接種疫苗>
      <疫苗名稱>HepB1</疫苗名稱>
      <預約接種時間>2007-01-03</預約接種時間>
      ・・・
      ・・・
      ・・・
    </接種疫苗>
    ・・・
    ・・・
    ・・・
  </預防接種紀錄>
</個人預防接種資料>
```

Figure 15 *Example of a Vaccination Record in XML Format*

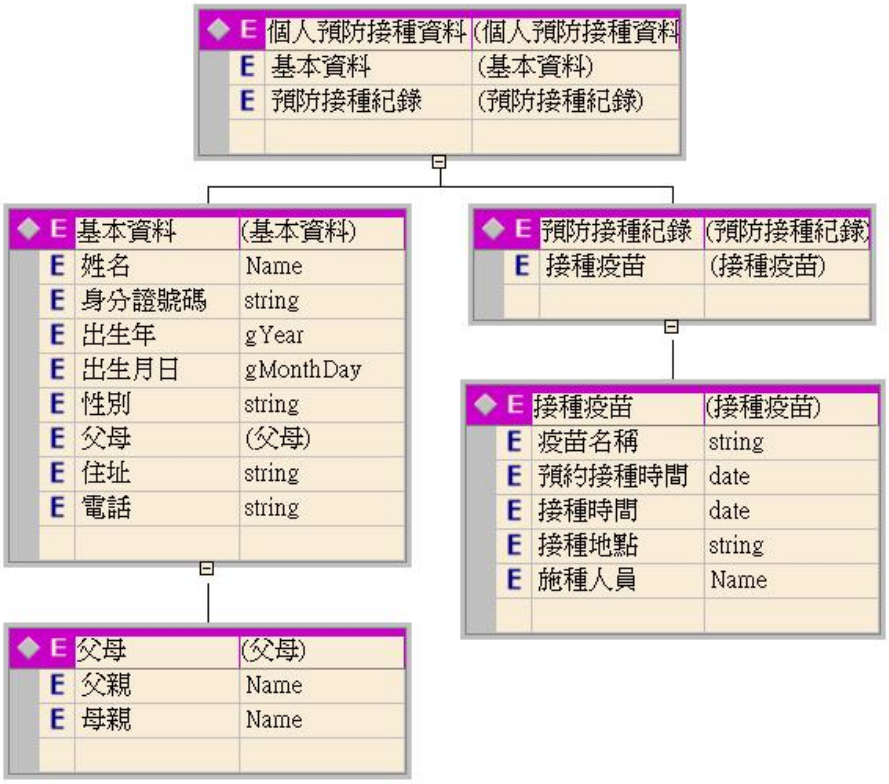

Figure 16 *XML Schema of Vaccination Records*

5.2.3 Operations

The major components of data mapping portion are “mapping” and “transform”, which are two modules added in legacy system to do the translation of data schema. In one case, when a local system transfers local data to central system, the mapping module maps the local schema to central schema. Besides, the data transmitted between local and central systems should be in XML format, so transform module changes the data into XML files according to the XML schema shown in figure 16. In another case, when data is transferred from central system to local system, the data received by local system are transformed to the format of local database data, and then the transformed data are mapped to local database schema before stored into the local database.

5.3 Communication and Control

5.3.1 Functions

The Communication and control portion is responsible for transmitting the vaccination records in XML format when there is a data exchange between local database and central database. Moreover, this portion also in charge of accepting the data query from web pages that demanded by end users, and then finds the right place to get the requested data.

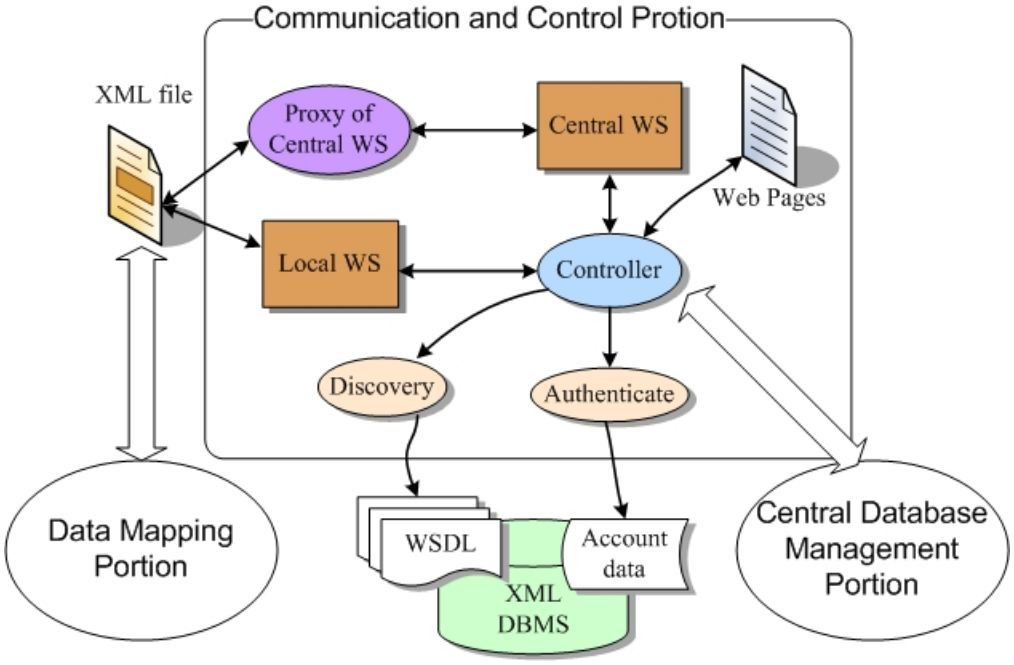

Figure 17 *Components of Communication and Control Portion*

5.3.2 Interfaces

For transmitting data, local and central systems use web services as interfaces for each other to communicate. In the local side, legacy systems in health bureaus may need to update their databases with vaccination records received from central system, so they must provide *Update* interface. For the service of looking up information about vaccines of medical institutions and health agencies, every legacy system has to provide *GetInfo* interface, though which central system can get the information.

In the central side, the central system provides *Download* and *Upload* interfaces to health bureaus. Health bureaus can get records from central database or transfer new records to central database. However, because of the consideration to personal privacy, contracted medical institutions should not have the authority to directly access to central database, so they can not use the two interfaces. There is another interface, *Referral*, is provided by central system. When referral procedure is needed, local systems (including any contracted medical institution and health agencies) can use the interface to send new records to central database and also update another local database with the records. The interfaces provided by local systems and central system and the annotations are arranged in the following table 4.

Table 4 *Interfaces Provided by Local and Central Systems*

	Interfaces	Annotations
Local Web Services	*Update*	Update local DB with new records (only provided by systems of Health Bureaus)
	GetInfo	Get information about vaccines
Central Web Services	*Download*	Get records from central DB*
	Upload	Send new records to central DB*
	Referral	Send new records to central DB and also update another local DB with the records

*Only systems of Health Bureaus can use the Download and Upload interfaces

5.3.3 Operations

According to what kind of service is used, the components operate in one of the four different processes.

a. When service of looking up vaccination record is used

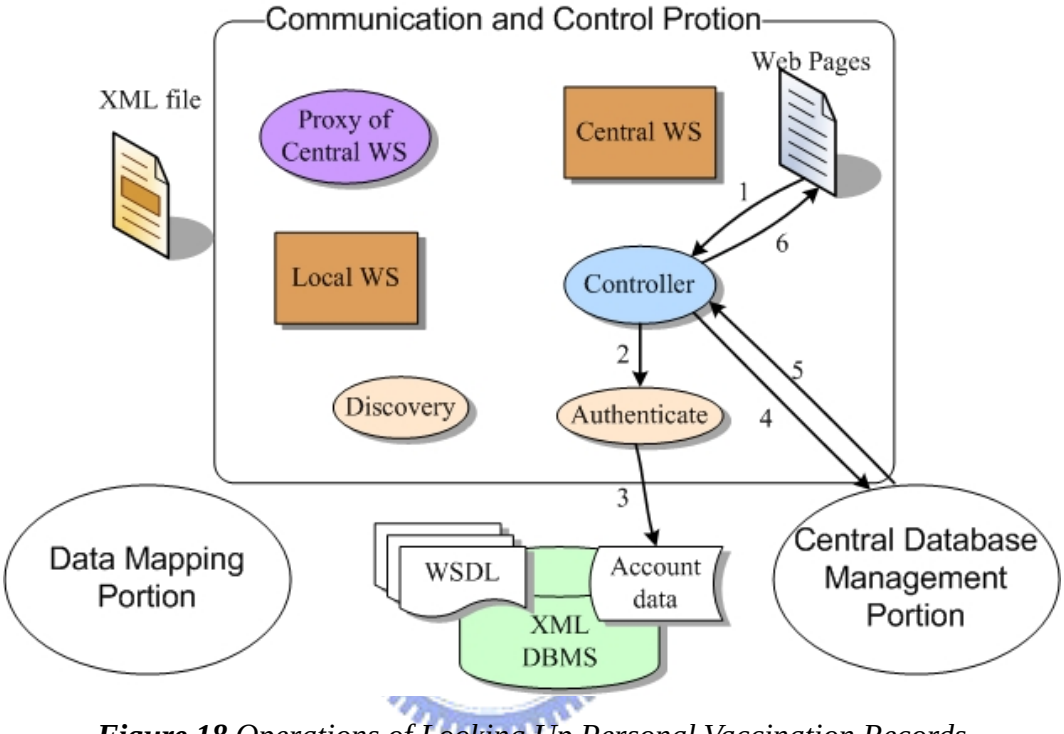

Figure 18 *Operations of Looking Up Personal Vaccination Records*

1. When a general user uses the web pages to look up his vaccination record, the web page send the identity and password of the user to Controller.
2. Controller then calls the *Authenticate* module to check the identity and password.
3. *Authenticate* module get the account data that are stored in a XML database to contrast with the inputted password.
4. If the id/password is correct, the Controller then sends the request to central database management portion.
5. Central database management portion return the queried vaccination record to controller.
6. Controller dynamically shows the vaccination record on the web pages.

b. When service of looking up information about vaccines is used

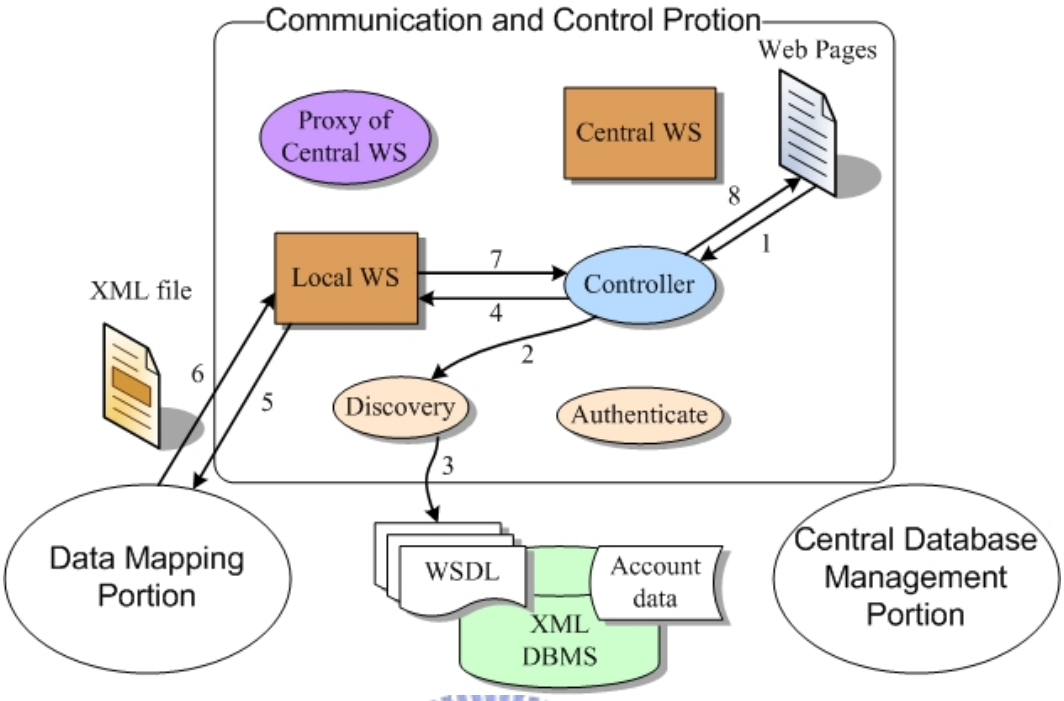

Figure 19 *Operations of Looking Up Information about Vaccines*

1. When a general user uses the web pages to look up information about vaccines in medical institutions, the web page send the search conditions entered by the user to controller.
2. Controller calls the *Discovery* module to find the web services provided by the health agencies or medical institutions involved with the requested information
3. *Discovery* module find the WSDL files of the involved medical institutions, which are stored in the XML database
4. Controller then connects to the local web services according to the descriptions in the WSDL files, and uses the *GetInfo* interface to sends the request.
5. The local web services send query to data mapping portion.
6. Data mapping portion in local system return the queried data in XML format to the local web service.
7. The local web service transmits the data to Controller.
8. Controller dynamically shows the information on the web pages.

c. When services of accessing central database from local is used

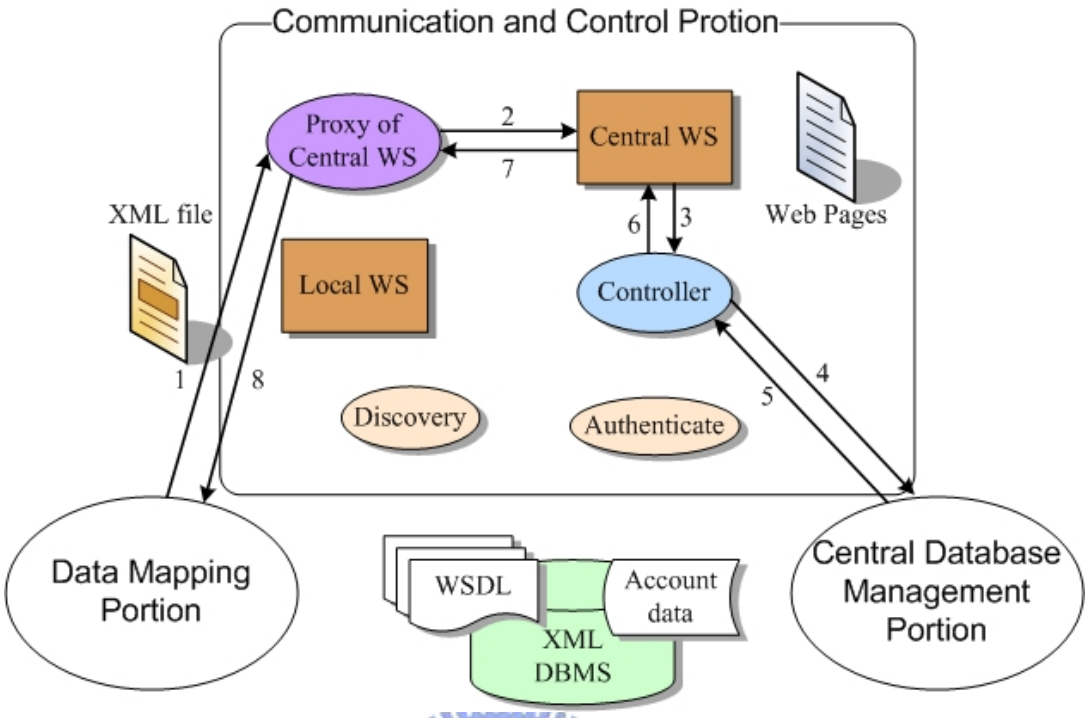

Figure 20 *Operations of Accessing Central Database from Local*

When local system want to upload data to central database

1. The data in XML format produced by data mapping portion is send to proxy of central web services.
2. The proxy of central web services transmits the data to central system through the *Upload* interface.
3. The central web services pass the data and parameters to controller.
4. Controller then passes the data to the central database management portion for updating.

When local system want to download data to central database

1.~4. Differing from uploading operations, data mapping portion only sends the query command through *Download* interface but not XML formatted data. Controller passes the query to the central database management portion.

5.~8. The requested data is return by the central database management portion, and transmitted back to local system through the connection established when sending the query command.

d. When service of automatic referral is used

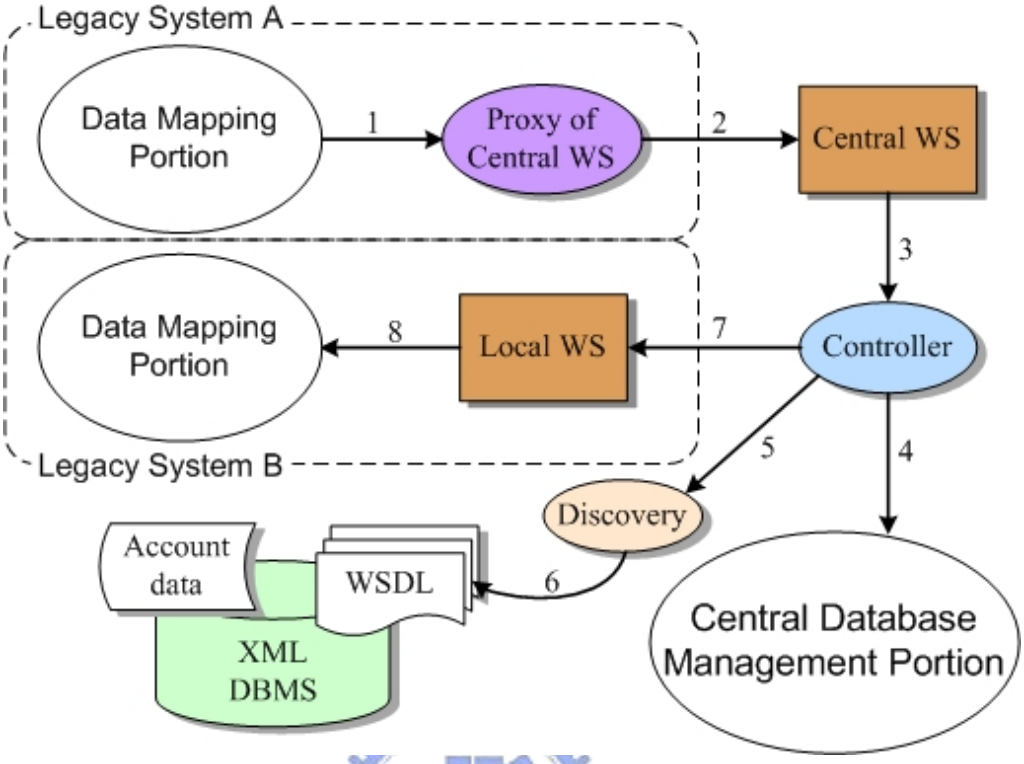

Figure 21 *Operations of Referral*

1. When the data in legacy system A needs to be transmitted to another legacy system B, the data from data mapping portion is passed to the proxy of central web service.
2. The proxy of central web services transmits the data to central system through the *Referral* interface.
3. The central web services pass the data and parameters to controller.
4. Controller first passes the data to the central database management portion for updating.
5. Then controller calls the *Discovery* module to find the web services provided by B
6. *Discovery* module find the WSDL file of B in the XML database
7. Controller then connects to the local web services according to the descriptions in the WSDL files, and uses the *Update* interface to send the data.
8. The local web service passes the data to data mapping portion for updating.

5.4 Central Database Management

5.4.1 Functions

The central database management portion is in charge of central database accessing and backup of the changed data. The controller in this portion receives vaccination records transmitted from communication and control portion, and then calls three managing functions to execute the transform, updating and backup.

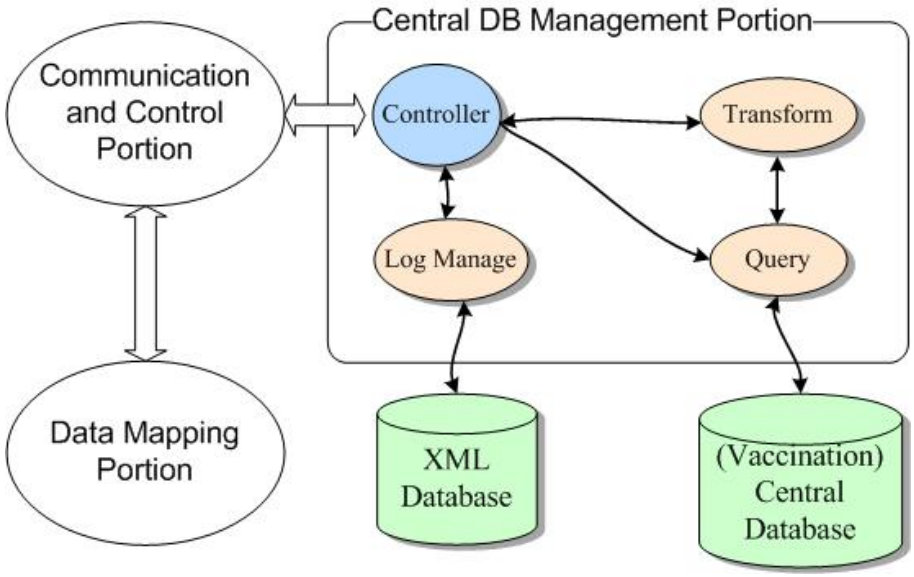

Figure 22 *Components of Central Database Management Portion*

5.4.2 Operations

When there are data from local system, controller first call *Log Manage* module to back up the changing log into the XML database. After that, the data is passed to *Query* module and then are updated to the central database.

If controller receives download query from communication and control portion, it call *Query* module to get the required data which is then formatted into XML file by *Transform* module. Finally controller returns the data in XML format to the communication and control portion.

5.5 Scenarios

In this section, by depicting scenarios that represents the general cases occurring everyday when people get vaccinated, we are showing how the designed On-Line Vaccination Services system simplifies the tasks of vaccination for workers on the base level and how it provides more accessibility to the general public.

5.5.1 Basic accessing to Central Database from Health Bureaus

Health Bureaus use the web services provided by central system to upload or download vaccination records. The controller in Web and AP server processes the requests from local system and queries the central database.

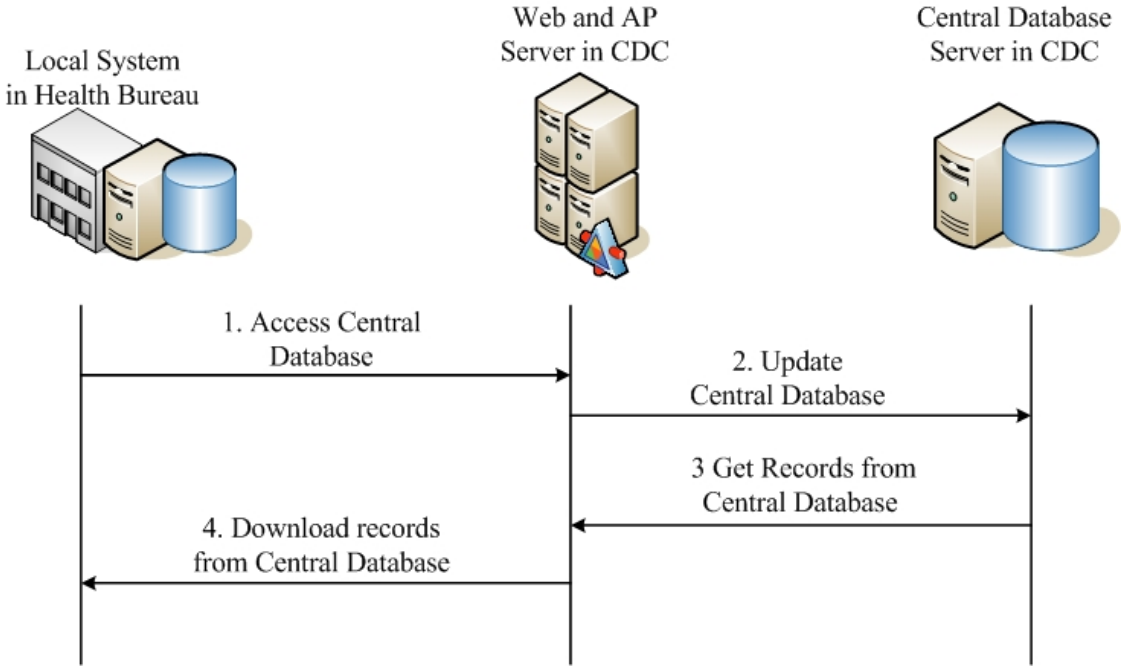

Figure 23 *Procedure of accessing Central Database from Health Bureaus*

5.5.2 Referral from Contracted Medical Institutions to Health Bureau

When someone goes to a contracted hospital or clinic to be vaccinated, the vaccination record should be send to the health bureau in his domicile. In our OVS system, the record is

transmitted to central server from the hospital or clinic in a uniformed XML format by using the web services that central server provides. Central server then will backup the XML file and update the central database. After that, central server sends the record in XML format to the server of the health bureau. The system of health bureau transfers the XML format to the database schema of its system and updates the data.

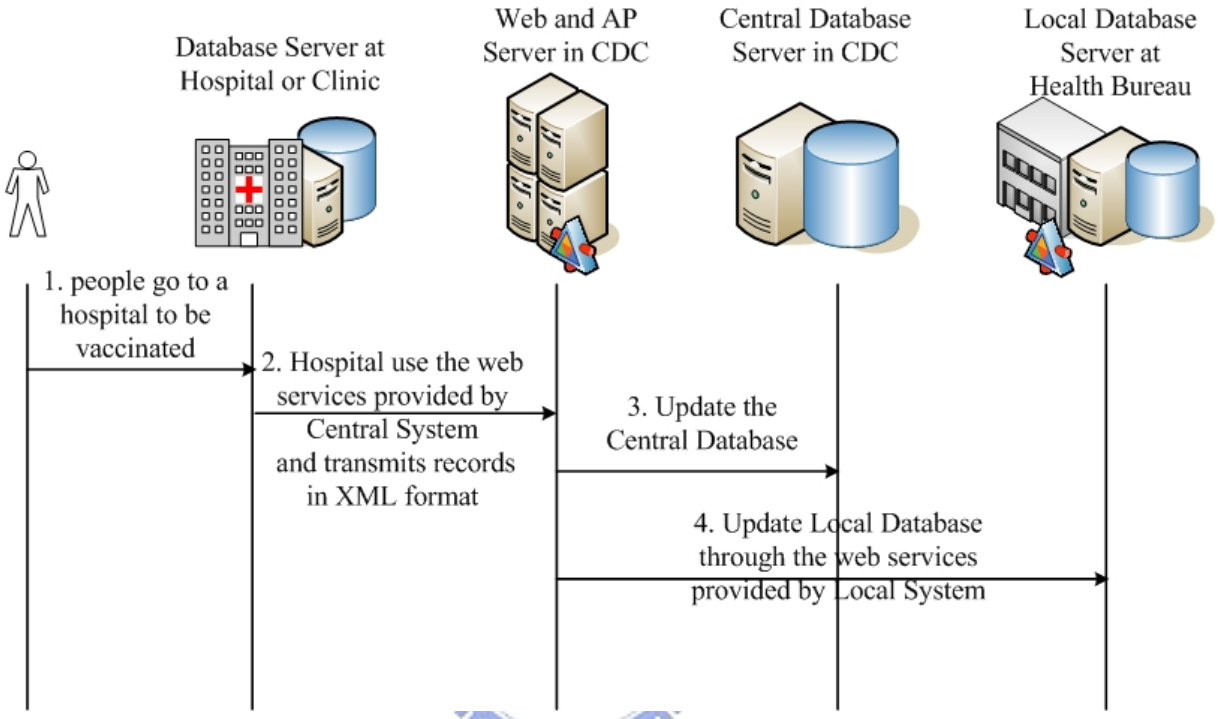

Figure 24 *Procedure of Referral from Medical Institutions to Health Bureau*

5.5.3 Referral Between Health Bureaus

When someone goes to get vaccination in a health center or another medical institution not located at his domicile, the vaccination record need to be transfer between Health Bureaus. The referral procedure between health bureaus and that between contracted medical institutions and health bureau are just the same. Record in a uniformed XML format is transmitted to central server from the health bureau not located at the person's domicile by using the web services that central server provides. Central server then will backup the XML file and update the central database. After that, central server sends the record in XML format to the server of the health bureau in the person's domicile, and the system of the health bureau transfers the XML format to the database schema of its system and updates the data.

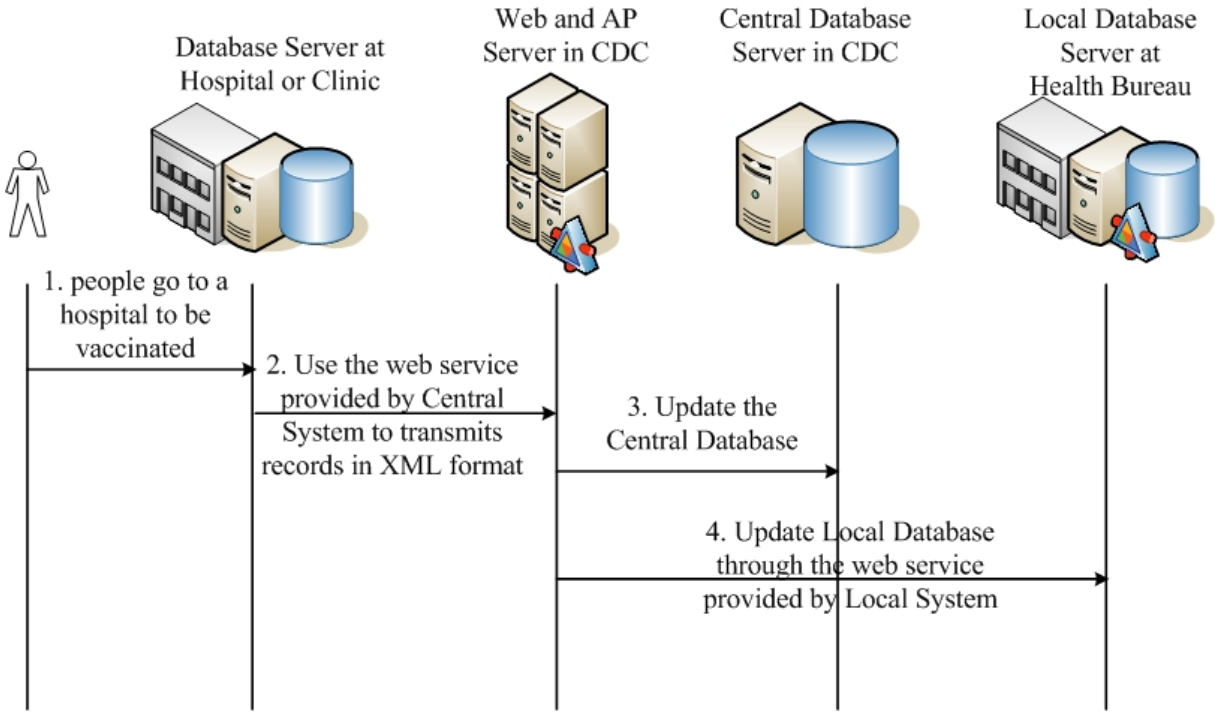

Figure 25 *Procedure of Referral between Health Bureaus*

5.5.4 Public Looking Up Their Own Vaccination Record

When someone wants to know whether a hospital has the vaccine he needs, he uses his computer with a browser to connect to home page of the On-Line Vaccination Services, and links to the search page. The user enters his account and password on the page, and then the server will query the central database to get the records and show then on the web page. The following figure shows the procedure of looking up personal vaccination record.

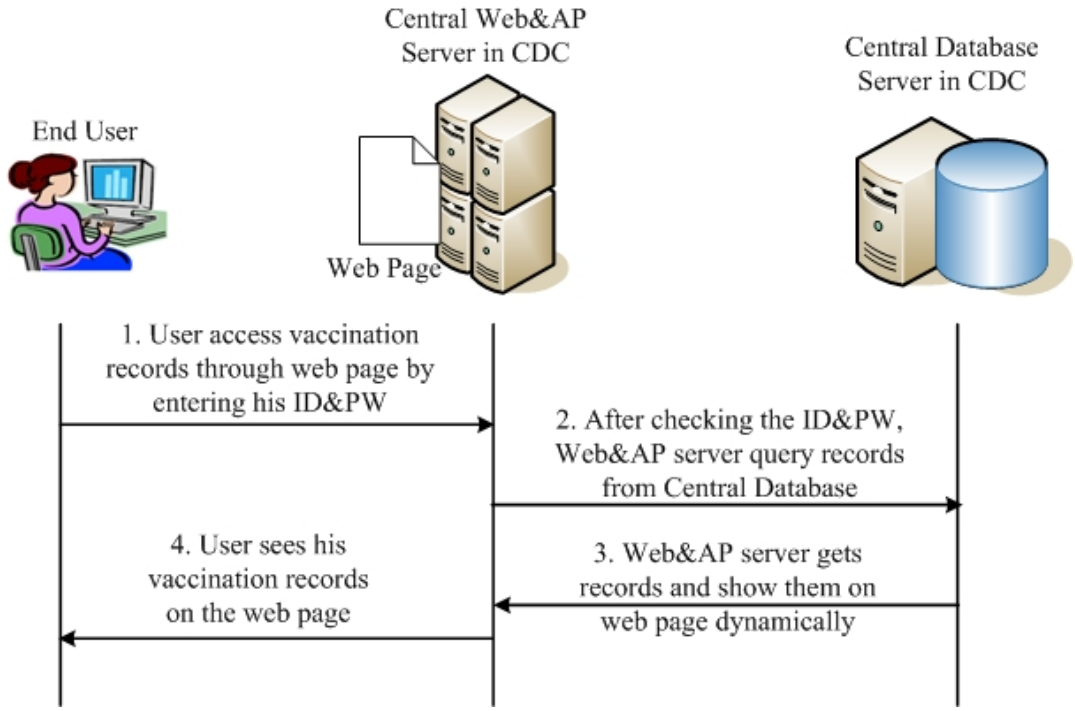

Figure 26 *Procedure of Looking Up Personal Vaccination Record*

5.5.5 Public Looking Up Information of Medical Institutions

When someone wants to know whether a hospital has the vaccine he needs, he uses his computer with a browser to connect to home page of the On-Line Vaccination Services, and links to the search page. On the search page, user can choose which vaccine he wants to inject, and the medical institutions in which district he is going to. After that the server know the institutions which have to be queried and where the web services of them located, according to the information and WSDL files stored in it, and then query the needed data using web services provided by the institutions. At last the result will be shown on the web page for the user to see. The following figure shows the procedure of users looking up information of medical institutions.

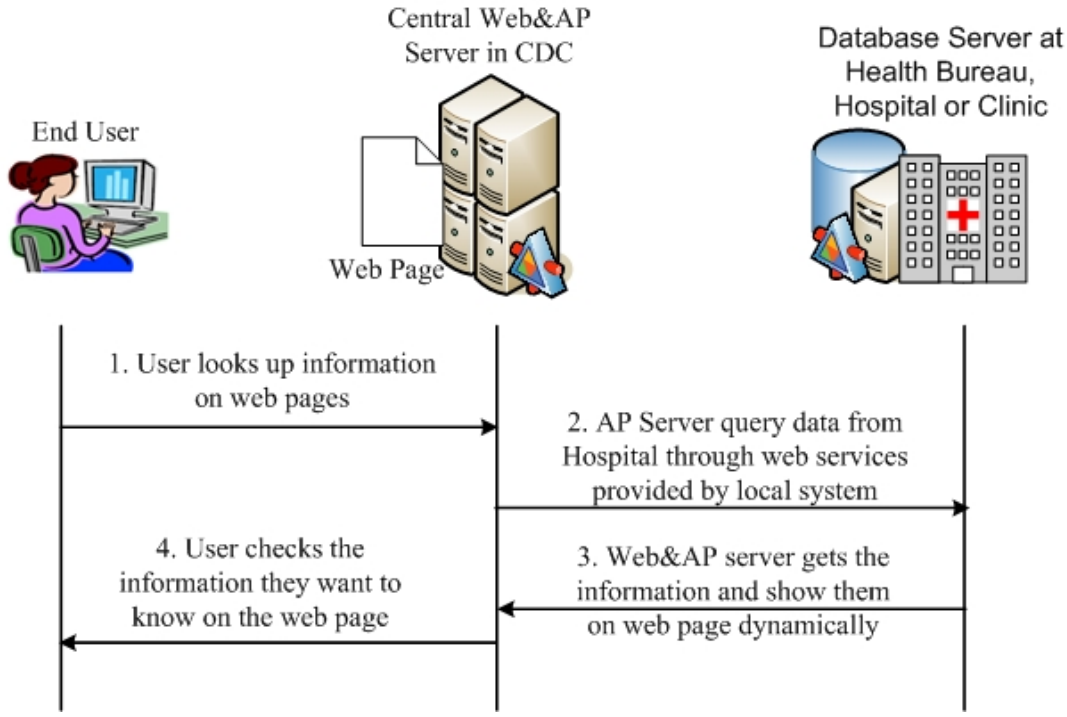

Figure 27 *Procedure of Looking Up Information of Medical Institutions*

Chapter 6 Conclusion and Future Works

6.1 Conclusion

Immunization program in Taiwan has been enforced since 1983, and what vaccines should be taken, at what age and what time, and the number of vaccination times are unified. People can get vaccinated at Health Bureaus of Contracted hospitals or clinics, and therefore the vaccination record may scattered in different places. Moreover, the preserving and managing of data are getting more difficult with the growing of population.

For the reasons described above, the government established National Immunization Information System in government health agencies. However, NIIS did not solve the problems thoroughly. However, by using NIIS, the data exchange still needs much manpower.

Taking advantage of Web Services, we designed a system that integrates existing heterogeneous and autonomous systems of government health agencies and contracted medical institutions to facilitate vaccination data exchange. Besides, our design also makes vaccination records more accessible for the general public.

6.2 Future Works

In OVS system, there could be more services on vaccination. One of the needing functions is the reminding service, which reminds people to get vaccinated at the right time. In addition, more efforts should be done on the security of the system, because the personal private data should have no risk leaking out.

Besides the basic vaccination services, OVS may be extended and adapted for other uses, e.g. the XML schema used in OVS can be adapted to fit the Health Level 7 and combine with electronic medical records that can be stored in everyone's National Health Insurance IC card. Moreover, since NIIS is now running, it may be a great benefit to integrate NIIS with our system.

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Appendix A – Immunization Schedule in Taiwan

Current Immunization Schedule in Taiwan

Vaccine / Age	≥24 hr	2-5 days	1 months	2 months	4 months	6 months	9 months	12 months	15 months	18 months	24 months	27 months	30 months	6 years	≥65 years
BCG	BCG														
Hepatitis B		HepB1	HepB2			HepB3									
Diphtheria, Tetanus, Pertussis				DTP1	DTP2	DTP3				DTP4				Td	
Polio				OPV1	OPV2	OPV3				OPV4				OPV5	
Varicella*								Var							
Measles, Mumps, Rubella¤								MMR1						MMR2	
Japanese Encephalitis**									JE1~JE2			JE3		JE4	
Influenza						Influenza（yearly）									Flu(yearly)
Hepatitis A#											HepA1		HepA2		

* Varicella vaccine is given to children born after January 2003 and aged 12 months or older.

**Two weeks interval between dose1 to dose2.

\# In selected aboriginal areas.

¤ From 2006 onward, Measles vaccine is removed from the immunization program and the age for receiving the first dose of MMR has been revised to be between 12-15 months.

Appendix B – Chinese and English Comparative Table of Vaccines

Vaccine Names in Chinese	Abbreviation	Vaccine Names in English
卡介苗	BCG	Bacille Calmette-Guerin vaccine
白喉、破傷風混合疫苗	DT	Tetanus and diphtheria toxoid childrens' dose
白喉、破傷風、非細胞性百日咳混合疫苗	DTaP	Diphtheria and tetanus toxoid with acellular pertussis vaccine
白喉、破傷風、全細胞性百日咳混合疫苗	DTwP	Diphtheria and tetanus toxoid with whole cell pertussis vaccine
A 型肝炎疫苗	HepA	Hepatitis A vaccine
B 型肝炎疫苗	HepB	Hepatitis B vaccine
b 型嗜血桿菌疫苗	Hib	Haemophilus influenzae type b vaccine
流行性感冒疫苗	Influenza	Influenza
注射式小兒麻痺疫苗	IPV	Inactivated polio vaccine
日本腦炎疫苗	JapENnc	Japanese encephalitis
流行性腦脊髓膜炎疫苗	Men C_conj	Meningococcal C conjugate vaccine
麻疹、腮腺炎、德國麻疹混合疫苗	MMR	Measles, mumps and rubella vaccine
麻疹疫苗	Measles	Measles vaccine
腮腺炎疫苗	Mumps	Mumps vaccine
德國麻疹疫苗	Rubella	Rubella vaccine
口服小兒麻痺疫苗	OPV	Oral polio vaccine
狂犬病疫苗	Rabies	Rabies vaccine
破傷風、減量白喉混合疫苗	Td	Tetanus and diphtheria toxoid for older children/adults
破傷風類毒素疫苗	TT	Tetanus toxoid
傷寒疫苗	Typhoid	Typhoid fever vaccine
水痘疫苗	Varicella	Varicella vaccine
黃熱病	YF	Yellow fever vaccine

Appendix C – Interview with a student about to study aboard in the fall of 2007

Following dialogue is extracted from the notes of interview with Lin Tsai-Yin, who will be studying in University of Minnesota for Ph.D. degree.

Q： Does your school request new students who are entering it for any physical examination or immunization record?

A： Every new student of our school has to do the tuberculin test and hands in an immunization form in which the vaccinated date of TD and MMR are filled. In Taiwan, TD and MMR should have been given to everyone when he was a child.

Q： In general, people don't remember when he/she took vaccines, then how did you get your records of immunization with certification?

A： People are supposed to have their own immunization records on a yellow card which was given to their parents when born, but my yellow card is gone. You can show the yellow card to a doctor and then he will certificate for the immunization records. But the vaccinations required from my school are not recorded on my yellow card.

Q： How did this happen?

A： My parents once lost my yellow card and then got a new one, but the record on the old card was not put down on the new card again, thus the old record were also lost.

Q： What did you do in this situation?

A： I went to the public health center in my domicile, and the clerk said that they only keep personal records for ten years and maybe the public health bureau has my records. So I went to the public health bureau, this time, the clerks said that the digital immunization records were established after 1990, thus they do not have records of people born before 1990.

Q： So you didn’t find your vaccination record?

A： No. At last I could only go to hospital to take the required vaccines again and get new certificates.

Q： Did you get into any trouble when get vaccination or do the physical examination?

A： It was so inconvenient that I had to go to five places to accomplish all the required examination and vaccination because there wasn’t any hospital can do all the stuffs in one time. Furthermore, there was no information about where I can go, so that I had to ask each hospital or clinic by myself which was time-consuming and time-wasting. It would be much better if there was maybe a web site for people like me to look up related information.

Appendix D – Interview with Staffs at Hsinchu City Eastern District Health Center

Following dialogue is extracted from the notes of interview with nurses of Hsinchu City Eastern District Health Center and a staff of Hsinchu City Health Bureau.

Q： How do you keep the immunization record of people under their jurisdiction?

A： The records are kept in the database located at Hsinchu Health Bureau.

Q： What is the procedure when a child comes to get vaccination?

A： After vaccination, we will login to the NIIS system with browser and find the child's data by enter in his name or his mother's name and his birthday, and then we can key in the new record.

Q： Then how do you get the vaccination record if a child gets vaccinations at contracted hospital or clinics?

A： Because the contracted hospitals and clinics do not use the same system as health centers, so they can not directly upload the records to our database. They export the data in a unified format and save in discs then mail them to health centers. In another way, they may send the records by e-mail. However, in both ways, they need to fill a referral clip (or yellow clip) for each referral case, and send the clip to health centers for double checking.

Q： Can people get their immune certification here if their yellow cards are lost?

A： Only people whose domicile in Hsinchu city can get their immune certification here.

Q： How does NIIS cope with the referrals?

A： Every night at twelve O'clock, health bureau's system automatically sends the records not belong to people under its jurisdiction to central server. The central server will contrast the information with database of Affairs of Household Registration, and transmit the record to the right place

Q： Are there any defects of NIIS which as you opinion should be modified?

A： The information about contracted hospital and clinics is deficient, which leads to the difficulty on managing vaccines. Besides, there is no national search system for vaccination records, so that it is inconvenient to check the cases out of the jurisdiction. Moreover, the data column for foreign nationals are not enough, therefore it is troublesome when checking children of foreign nationals. In additional, the speed of data transfer is too slow, and