

Development and deployment of a web-based physician order entry system

Yen-Liang Lee ^a, Chien-Yeh Hsu ^{a,*}, D. Hsieh ^b, Yu-Chuan Li ^a

^a *Taipei Medical College, Graduate Institute of Medical Informatics, Taipei, Taiwan*

^b *Information Department, Kang-Ning General Hospital, Taipei, Taiwan*

Abstract

The computer-based Physician Order Entry System (POES) has been employed in many clinical institutes in Taiwan. Most of the POES systems are developed in the two-tier client-server architecture, and a large portion of the systems are constructed on a mainframe or even a single PC.

The exponential growth of the Internet has had a tremendous impact on our society in recent years. In consideration of the future user interface and system architecture, we have developed a three-tier web-based Physician Order Entry System and successfully deployed it in the Wang-Fang Hospital in Taipei.

The system is the first POES based on three-tier and World Wide Web (WWW) in Taiwan. The system provides the Subjective, Objective, Assessment, and Plan (SOAP) structure for the physician to enter subject, object, diagnoses, medicine dosage, treatment and laboratory test request, and prints out the prescription and necessary document. The doctor can also retrieve the patient's medical record on the system. One of the special characteristics of the system is its personalized design. The doctor can define their own diagnosis, medicine and treatment database and any combination of these to facilitate their clinical work.

The system has been reviewed since February 1999. The result shows that the clinical procedure has become more efficient, and the chances of omission have been reduced. The system is very stable and the Open Database Connectivity (ODBC) database access did not show any delay in the network. Since we have incorporated many new web-programming techniques, the progress of the techniques will improve the system performance in the future.

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1. Introduction

The Physician Order Entry System (POES) has become an important part of the Hospi-

tal Information System (HIS) especially in the development of Electronic Patient Records (EPR) [1,21]. The basic function of a POES is to let the doctors file orders and inquire of the patient's record. In this paper, we will present a three-tier web-based POES that uses the ordinary web browser as the

* Corresponding author.

E-mail address: cyhsu@tmc.edu.tw (C.-Y. Hsu).

interface and is developed by the computer center in the Taipei Medical College.

The computer-based Physician Order Entry System has been employed in many clinical institutes in Taiwan. The IT industries Network [2] indicated that the computerized physician order related products would be one of the national leading products in Taiwan. In medically related industries, many companies are good in the basic skills for building a medical network but usually need high-level technology. In the future, the electronic patient's record, medical image system, and remote medical service system will bring lots of marketing values.

Another official medical page also indicated that after installing the POES on line, doctors could use the computer to retrieve the patient's medical history fast and very easily¹. In particular, the system gives the doctors more useful data about the patients in a shorter time, thus enhancing the quality of medical service. Their report also stated that the physician order entry system was connected with the laboratory information system, the pharmacy system, and the material and operation room management system. Therefore, doctors can use the computer in the clinic to obtain all the necessary information and resources, and this reduces the time for the arrangement of medical treatments.

There are many researches and products related to physician order entry systems on the market [3-7]. The basic functions include recording subjective and objective, entering diagnoses, medicine, treatments and ordering laboratory tests. Some products also include specialized order macros, medical history retrieval, clinical record management, pharmacy and material control.

Although many clinical institutes in Taiwan have employed the computer-based POES, most of the POES systems are developed in the two-tier, client-server architecture, and a large portion of the systems are constructed on a mainframe or even a single PC [8-10]. When we evaluated the present POESs installed in many institutes, we found that those systems are operated either by the doctors themselves or by assistants. If the POESs are just used for input orders (and these kinds of systems are usually used by assistants), a text mode interface is usually adopted for the purpose of fast typing. But, if the POESs are used by doctors, then a graphic user interface is required, and many advanced functions are also implemented.

2. Background

Since the client/server architecture has become increasingly popular, the distributed processing has played a very important role in the network technology. In recent years, the Internet, together with the three-tier structure, the Presentation Tier, Logic Tier, and Data Access Tier, has been widely adopted in the integration of World Wide Web (WWW) applications [9-14]. On the Internet, users can obtain information from anywhere in the world. Together with multimedia, many applications can provide users with a friendly interface and efficient data access. The traditional HIS can be accessed only inside the hospital. Therefore, there the transfer of medical information is limited. However, if we can apply WWW technology to the development of HIS, we believe that there will be many improvements on the data exchange, user interface and platform flexibility.

¹ (<http://www.doh.tpg.gov.tw/pub/taihyge/363/html/09-1.html>).

Generally speaking, the advantages of the three-tier web-based architecture are:

1. Cross platform: the computer's operation system is almost independent of information exchange.
2. Convenient: integrating with the present information system in the hospital, we can provide information globally.
3. The cost of the hardware is relatively low.
4. The WWW is capable of processing multimedia medical data, including text, image, video and audio, flexibly.

The ordinary HIS in the Wang-Fang Hospital was based on a traditional two-tier client/server architecture. The hardware and software have been changed once to solve the problem of the delay of database access. However, there are still some problems including difficulty in the version control and program distribution.

Since the number of outpatients has continued to increase in the Wang-Fang Hospital recently, the most urgent problem is that there is an insufficient number of front desk clerks, and there has been a bottleneck in the clinical pathway. Therefore, the main functions of the first stage of the POES are to create a simple interface to let the doctors enter diagnoses, treatment, and medicine, and to send the order to the charge system.

The computer center in the Taipei Medical College has a lot of experience on the development of medical related applications. Considering the future user interface and system architecture [15], we decided to develop a three-tier web-based Physician Order Entry System (POES). Furthermore, the system was designed to become a fully functional physician workstation in the future. Therefore, our target end users would be the doctors, and the system was planned to provide more useful functions that would help the doctors do their job more efficiently.

3. Methods

In the present time, the Wang-Fang Hospital in Taipei has been selected to install and deploy the web-based POES system and will be evaluated in the future. When examining the database connection and interaction on the network, we found that the system has exhibited its flexibility and compatibility with the original HIS in the Wang-Fang Hospital.

The system was designed under the following considerations:

3.1. *Highly compatible platform*

The selection of the web server, database and development platform is conducted very carefully. Since the HIS, the database and the operating platform have been established in the Wang-Fang Hospital for a period of time, the POES's system architecture has to be considered very carefully so the target POES will work with the present system without any problem.

3.2. *High stability*

The system is installed in a real hospital not just a simulation, so the stability of the system is very important. A stable system usually gives users more confidence. The error correction has to be in real time, and the data transmission must be correct.

3.3. *Minimum impact*

When considering that the doctors have used the handwriting order forms for many years, and the policy of the hospital could not be changed fast, we think the new POES should have too much of an impact on the doctors. The interface of the system has to be designed in a way that will not change the doctors' normal clinical procedure and will not increase the clinical time.

3.4. Personalized design

According to the differences in practice between the different clinical departments and even individual physicians, the contents of the general tables including the medicine table, the diagnosis table and the treatment table in POES should be designed for different clinical departments.

The three-tier architecture used for POES includes the presentation tier, the logic tier, and the data access tier. The three-tier structure can reduce the loading of the database server and have more flexibility when integrated with different database systems.

Since the Oracle database (Oracle 7.0) and the UNIX operation system have already been used in the Wang-Fang Hospital, we will not change the original platform. Microsoft's Internet Information Server (IIS 4.0) was selected to construct the three-tier architecture. The Active Server Pages (ASP) [11] were executed on the IIS. The Internet Explorer (IE 5.0) was selected as the web browser in the client computers. This architecture is very simple and can provide a powerful development platform. The web browser in the client utilizes the Distributed Component Object Model (DCOM) to communicate with the objects in Microsoft Transaction Server (MTS) [12,16–20]. In a multi-user system, the efficiency of sharing resources is very important. The MTS provides the sharing for the database connection, the executing queue and the objects. The objects can be used repeatedly, so that the system can save some memory.

Microsoft's Open Database Connectivity (ODBC) was selected to communicate with the Oracle database, because ODBC is compatible with a variety of database systems. The ActiveX Data Object (ADO) and Remote Data Service (RDS) [13] were used to provide the database connection and will be evaluated in the future.

Microsoft FrontPage was selected as the development tool. Microsoft FrontPage has the ability to build and maintain a station on the Internet or Intranet very efficiently. Microsoft Visual InterDev was used to develop the ASP, dynamic HTML (DHTML) and Cascading Style Sheet (CSS). Microsoft Visual Basic 6.0 was used to develop the objects on the Microsoft Transaction Server.

4. System description

The system is the first three-tier web-based POES installed in a hospital in Taiwan. The deployment program was conducted very successfully and smoothly in the Taipei Wang-Fang Hospital. The utilization of the system from February 1999 to May 2000 is shown in Fig. 1. The access number has reached 33000 patients per month, which is more than 45% of the total outpatients of the Wang-Fang hospital. This situation confirms the possibility and stability of using the Internet techniques to develop the hospital information system (HIS).

The functional diagram of the system is shown in Fig. 2. Doctors can use this system to enter orders, write patients' records, and transfer the data to the HIS's database and the charging system directly. When replacing the handwriting order with the computer-generated order, we found that the chance of error occurrence has been reduced. Most of the order input procedure can be completed by using the equipped mouse and touch panel in every client computer, thus reducing the resistance of using this system in the beginning.

Fig. 3 shows the main order screen of the system. We can see that the doctor can use the system just like using an ordinary browser, and this reduces the training cost and practice difficulty tremendously.

The system provides the full SOAP structure for the physician to enter subjective, objective, diagnoses, medicine dosage, treatment and laboratory test request, and prints out the prescription and necessary document. The doctor can also retrieve and edit patients' medical records on the system very easily and safely. The ditto function of the system can retrieve previous clinical records, and this saves a lot of time for the doctor in reviewing and examining patients' records.

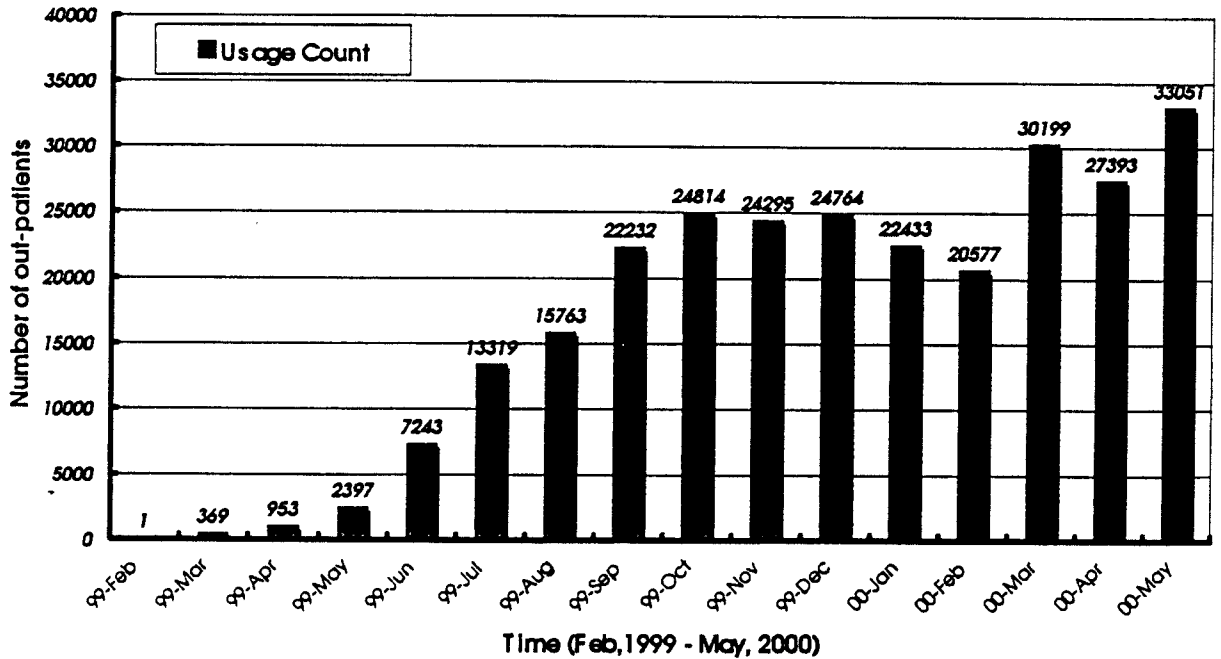
All the interface and selection tables are optimized according to personalized designs, which are organized by different departments or physicians.

The doctor uses the preview function to review the entered order. Also, the system issues a warning message and some sugges-

tions if the order contains any medicine that is out of stock or already on a 'stop-using' status. This function reduces the chance of changing the orders and helps doctors select medicine.

Because the system is a three-tier web-based application, the method of accessing the database was on a connectionless mode. This means that the system will establish a connection to the database only when it wants to transfer data, therefore reducing the load of the database server. According to our examination, the average write-back time can be limited to 4 s. So, in Wang-Fang Hospital, which has 37 clinics equipped with our POES, the total system efficiency is almost the same as that on a single computer application.

Utilization of POES system



ES system utilization from February 1999 to May 2000.

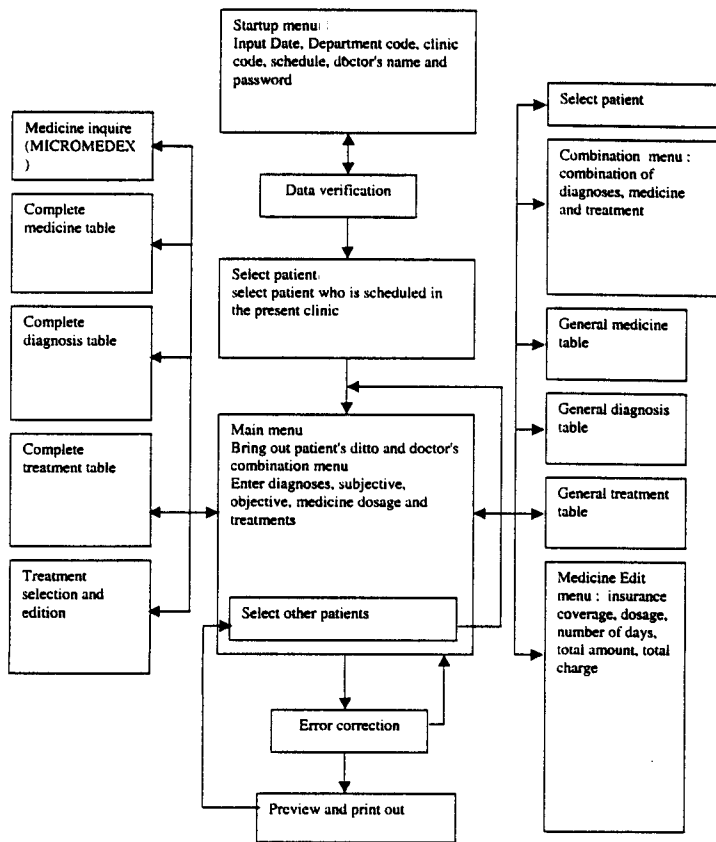


Fig. 2. Diagram of the functions of the POES system.

5. Discussion

5.1. Promote clinical efficiency

The POES system has been arranged in 37 clinics in the Taipei Wang-Fang Hospital. Utilization has become more than 45% of the total outpatient unit. The system has improved the clinical efficiency and the correctness of the doctor's orders. By using the computer, the doctors can obtain all information about patients' medical histories, thus increasing the speed and accuracy of the decision and treatments. Furthermore, inputting the medical record using the computer is more convenient than handwriting, and the computer record is easier to access. The sys-

tem also enhances the accuracy of charge capture function in the hospital. In general, the system has improved the whole clinical quality and efficiency.

5.2. Possibility of using the internet technology

From a technical point of view, there are some disadvantages to the web-based system. For example, the flexibility is not good enough, especially on the formatted printout, connection to the database is not as easy as traditional applications, and different browsers are not compatible with each other in the HTML format. However, there are many advantages in using the web-based sys-

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