DEVELOPING AN ONLINE PATIENT APPOINTMENT SCHEDULING SYSTEM
BASED ON WEB SERVICES ARCHITECTURE

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ABSTRACT

Currently, many healthcare providers in primary health care use computerized information systems to a certain extent. However, the problem of heterogeneous information sources has impeded the integration of health care information within primary health facilities. How to facilitate information sharing among the different healthcare providers has been recognized as a growing area of significant importance due to its role in enhancing patient centered, continuity of care. However, the design and implementation of integrated health information system is challenging due to the heterogeneity and autonomy of different clinical specialties and differences in ownership of clinical practice and resulting differences in information systems that they use. The emergence of the Web Services Technologies brings the opportunity to addressing the above challenges by using new set of technological solutions. This paper proposes an online patient appointment scheduling system based on the Web Services architecture. The analysis and implementation results show that the Web Services architecture provides an ideal design paradigm for the development of integrated health care information system in the primary care setting.

Index Terms—Primary health care, Web services technology, SOAP, HTTP, Extensive Makeup Language (XML),

1. INTRODUCTION

Over the last two decades, the primary health care (PHC) has become the most important healthcare service in many developed countries. This is because it provides continuing and universally accessible health care services to the local individuals and families in a community [1, 2]. In recent years, the concept of “patient-centeredness” has become the norm in primary health care [3]. In comparison with disease-centered, technology-centered or physician-centered health care practices, the patient-centered primary care practice requires care providers to consistently address patients’ concerns and adequately share management options with patients [4, 5]. David et al. illustrated main characteristics of patient-centered primary care practice [3], including patients can easily access primary care services and elicit information that is most important to them, design and implement integrated clinical information system that supports smooth information transfer between different primary care practitioners [3].

As a response to this paradigm, there is a trend for the development of integrated and better coordinated PHC services across the full range of different care providers, such as General Practitioners (GPs), physicians, specialists, therapists, and even alternative medicine practitioners, to optimize patients’ medical services through a single service entry point that minimizes the reliance on external resources [6, 7]. Archiving such integration requires the establishment of a loosely coupled and broadly-based enterprise in which different health care providers collaborate in pursuit of a common set of objectives [6, 8]. Current health care organizations, however, own large number heterogeneous information sources that impeded the information sharing and exchanging within primary health [9]. This is because most of current existing health care systems consists of isolated, stand-alone applications operated by different Database Management Systems (DBMS) [9-11]. The following scenarios illustrate the heterogeneous problem in a regional medical centre:

- The main clinical system, which is mainly used by GPs, is installed on the Windows Server platform, serving for various tasks, including patient appointment scheduling, bulk billing, patient medical information recording and updating, etc. All operations are managed by Windows SQL Server.
- The allied health practitioners use a different system installed on the Linux platform for patient scheduling and medical recording. This application is managed by a Linux Open Source Database Server.
- These two clinical information systems are operated separately by practitioners with different workstations. These workstations are connected to the internal Intranet, creating a distributed computing environment. However, due to the differences in system platform and DBMS, patient
information cannot be shared or exchanged across these two systems.

From above description, it can be seen that the key challenge to achieving integrated PHC services is to create an infrastructure that can uniformly integrates medical data from heterogeneous information sources and deliver them to the relevant individual who need it at every point of care [12-15].

Addressing this challenge as a growing area of concern, extensive studies have been conducted [16-20]. Among these studies, the Web-Services technology is introduced into the health care information system development [21-23]. It has been used as a unified platform to supporting integration of disparate systems in computer industries [24]. This approach uses a commonly-agreed and general technical mechanism for assembling software components in a modular way and invoking services exposed by an information system [25-27]. It is built on a set of baseline specifications, which include Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL), and Universal Description, Discovery, and Integration (UDDI) [28]. As a result, any system capable of parsing text and communicating via a standard Internet transport protocol, such as HTTP, SMTP or XML, can communicate with a Web Service [28-30]. A centralized Web service can enable seamless integration of various clinical information systems in different settings and provide universally accessible medical services to patients.

Easily making an appointment with preferred date and time is a main characteristic of patient-centered primary care practice [3]. To enable the establishment of patient-centered primary health care, an integrated online patient appointment scheduling approach based on Web-Services architecture is proposed in this paper. The goal of this research is automated patient appointment scheduling process by integrating distributed clinical systems into a set of consistent and convenient services accessible via a web browser. The overall system architecture is illustrated in Figure 1.

The middle-tier uses a web server to connect to the Internet and handles the HTTP requests exclusively for the static contents, such as static HTML files and images. It responds user’s request with HTTP protocol, such as sending back a HTML pages. In case the HTTP request is related to patient appointment scheduling services, the web server will delegate the dynamic response to another server-side application located at application server to process the request. The results response from application server will be converted into HTML format through web server and displayed in the standardized HTML Web Page.

The overall architecture of proposed appointment scheduling system is shown in Figure 1. As there already were several clinical information systems such as Medical Director 3 (MD3) for general practitioners (GPs) in the medical centre, a three-tier architecture was developed to enable communication and information exchange between the online appointment system and the existing clinical information systems (CIS), or be scalable to integrate with any CIS that will be introduced in the future. In the first-tier, patients can access appointment information with a web-browser through Internet. The third-tier enterprise information tier (EIS) is composed of a group of adapters to connect with the existing CIS or any future CIS. The middle-tier connects the first tier with the third tier for information exchange. The overall system architecture is illustrated in Figure 1.

Finally, Section 5 concludes this paper and outlines the future work.

2. THE OVERALL ARCHITECTURE OF ONLINE APPOINTMENT SYSTEM

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Figure 1. The architecture of proposed patient appointment scheduling system

User login and registration requests are processed by the portal server which located in middle tier. The security mechanism in login process is enhanced through a MD5 hash generator. This encrypted login procedure ensures that only identified users can access the relevant medical resources.
The application server is a component that manages the complete end-to-end appointment tracking and scheduling services. The key functions of application server include: (1) multiple-practitioner scheduling, (2) centralized and consolidated patient appointment tracking, (3) available appointment searching, (4) appointments rescheduling, and (5) appointment confirmation and cancellation.

A middle-tier database is used to cache the data retrieved from EIS-tier database in order to minimize network traffic flow and disk access. In addition, detailed information about each scheduled appointment slot, such as patient login and contact information, is also stored into the middle-tier database.

The message exchange server is designed to provide gateway services to facilitate the assembly, dispatch, receipt and assimilation tasks. It is developed to meet all integration requirements within heterogeneous clinical information systems. In such a way, additional clinical systems can be subsequently integrated into the system through the use of so-called “adaptors”. In addition, a set of common libraries and infrastructure components are developed and applied by message exchange server to make the whole architecture extensible. The key functions of message exchange server include: (1) dispatch and receive messages between external and internal entities, (2) assemble and assimilate messages that entering and existing core clinical applications, (3) standardize integration procedures such as event logging, exception handling and auditing, and (4) cache the appropriate appointment information in order to improve system performance.

The appointment adaptors in the third or EIS tier are used to retrieve and transfer appointment information from the heterogeneous clinical databases into a well-formed XML document for transmission. These adaptors provide unified interfacing between the clinical information systems and message exchange server. The message exchange server acts as a standardized interface between clinical information systems and the middle tier. New adaptors can easily be developed to support other clinical systems, such as pathology or preventive health care systems. With the utilization of adopters, the amount of development efforts required to build extensive applications are minimized by means of using standardized common libraries and components developed to overcome the heterogeneous problems.

The current existing clinical information systems (CIS) in the EIS tier, including GP system and the allied health system, are regarded as heterogeneous and autonomous information sources that store the information about patients, practitioners and appointment scheduling. These systems are integrated with application server through adapters and message exchange server.

3. THE IMPLEMENTATION OF ONLINE APPOINTMENT SYSTEM

The online appointment system was developed by the first author and installed in a server machine in the CHC at the end of January 2011. There is a web link at the home page of the medical centre Web site, clicking on it would allow a person to enter the web-based online appointment system.

Information about the online appointment system was disseminated to consumers through the following channels: (1) fliers to be left at the reception desk for anyone to take for fee; (2) posters placed at the prominent locations in the medical centre; (3) advertisement at CHC web site. The information disseminated includes the web link to the online appointment system, the steps to follow to make an appointment using the online appointment system. Figure 2 shows the patient login web page.

![Patient Appointment Information](image)

Once a patient has successfully logged in, the appointment selection web page will be displayed as shown in Figure 3. The patient can select their preferred appointment date, time and doctors. If the initial preference cannot be met, an alternative choice will be presented automatically, including the available time, date and doctors in the medical centre. After patients make their final choice, a confirmation web page will be displayed as shown in Figure 4.
The confirmation web page provides an opportunity for patients to reconsider their choices before the information is finally stored into the database. It displays start and end time of the appointment, patient’s name and doctor’s name. Patients can reselect a new appointment slot or cancel the current selection. Once the patient clicks “Confirm” button, the appointment confirmation service is involved and the appointment information will permanently be stored into the clinical database. Then the system will generate a confirmation e-mail letter and send it to the patient’s e-mail address.

4. IMPLEMENTATION RESULTS

Figure 5 shows the adoption rate of online appointment after three months of implementation. The adoption rate of the online appointment system was gathered from the log record of the online appointment system. It was increased steadily from 3.20% to 3.78%, then 4.40% at four, five and six months after the online appointment system went alive. The patient throughput in the medical center per day is around 300 people, among them 10, 11 or 13 people made their appointments to see their GPs through online appointment system in the 4, 5, or 6 months after the online appointment system was implemented, respectively.

The diffusion of innovation theory indicates that the adoption process can be divided into five segments: innovators, early adopters, early majority, late majority and laggards [31]. Rogers suggests that innovators constituted around 3% of the total population [31]. As it is shown in the Figure 6, the overall adoption rate of the online appointment system had slowly increased from 3.2% to 4.4% over the three months survey period. It appears that only the innovators in the patient population had adopted the IT innovation – the online appointment system. The innovators were belonged to the 15% of the patient population who used the Internet to access the web site of the medical center. This may indicate that Internet-based healthcare delivery is still far from the reach of the general public in the regional Australia, where the study site belongs. However, 61% of the patient population expressed their intention to use web-based self-service applications. This information is supportive of Australian government initiative of introducing Personal Controlled Electronic Health Record System (PCEHR) in Australia.

5. CONCLUSION AND FUTURE WORK

This paper proposed an online patient appointment scheduling system built on the Web Services architecture in a heterogeneous healthcare environment. It shows that the Web Services architecture provides an appropriate paradigm for the development of an integrated health information system.
system which enables the communication among heterogeneous, autonomous and distributed healthcare information systems. The prototype system demonstrates the feasibility of the architecture. The future work will be focused on integrating the new clinical applications into the system.

This case study serves as a preliminary study for the future analysis of consumer’s acceptance and usage of e-Health applications, such as PCEHR in primary health care in regional Australia. Future statistical analysis of qualitative and quantitative results will be undertaken to improve our understanding of the patient’s behavior in adopting e-health application and the factors that impact on the adoption behavior. Our preliminary findings are highly valuable for the decision makers charged with the responsibility of implementing PCEHR to consider in designing their strategies and plans for the introduction of the PCEHR system in regional Australia.

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11. REFERENCES


