An Integrated Healthcare Enterprise Information Portal and Healthcare Information System Framework

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Abstract—**The paper presents an integrated, distributed Healthcare Enterprise Information Portal (HEIP) and Hospital Information Systems (HIS) framework over wireless/wired infrastructure at National Taiwan University Hospital (NTUH). A single sign-on solution for the hospital customer relationship management (CRM) in HEIP has been established. The outcomes of the newly developed Outpatient Information Systems (OIS) in HIS are discussed. The future HEIP blueprints with CRM oriented features: e-Learning, Remote Consultation and Diagnosis (RCD), as well as on-Line Vaccination Services are addressed. Finally, the integrated HEIP and HIS architectures based on the middleware technologies are proposed along with the feasible approaches. The preliminary performance of multi-media, time-based data exchanges over the wireless HEIP side is collected to evaluate the efficiency of the architecture.**

I. BACKGROUND AND PROBLEMS

THE healthcare information system (HIS) in National Taiwan University Hospital (NTUH) was built under IBM/SNA (Systems Network Architecture) OS390 environment with hierarchical IMSDB databases over twenty-five years ago. Basically, in the 80's, the system provided stable, high performance, especially reliable features suitable for handling critical, medical data and demographic records. The HIS contains multiple components operating independently, e.g., Outpatient Information Systems (OIS), Inpatient Information System (IIS), Emergency Treatment Information System (EIS), Laboratory Information System (LIS) as well as Radiology Information System (RIS) with PACS (Picture Archiving and Communication System) feature. The Client/Server approach was designed and implemented in the system [1] [5].

As time advancing, the built-in technologies have been obsolete. In addition, an integrated accessing among the HIS components have become inevitable. There are problems occurring as listed below:
1) The annual maintenance charge of the IBM HIS system is significant. The expense has turned out to be a heavy burden for NTUH financially.

2) In recent years, the healthcare regulations are changing rapidly in Taiwan. Under the circumstances, the HIS system needs to reflect the modifications and enhancements correspondingly. There are new demands acquired by the NTUH faculties and staffs either medical or administrative related issues to cope with the advancing and improving technologies, for examples, user friendly Web browsing features, wireless connections, e-Learning environment, etc.

3) The security issue of the legacy system has raised attentions. As depicted before, the legacy HIS includes multiple systems operating individually. In other words, each system has its own authentication and authorization procedures. While users, i.e., doctors or assistants, operating among different systems, they need to login each system separately. This multiple login processes disturb doctors and staffs. It also generate resistances and causes the system's usage downgrade or undesirable.

Furthermore, there were cases that doctors avoid the login process (for conveniences), and simply provide usernames and passwords to the assistants and ask them to operate for him/her directly. This situation can cause security concerns regarding the correctness of patient's records and data. Later, it can generate threats to patient's health or life. A Single Sign-On facility is necessary.

The definition, design and future architecture of HEIP with value added CRM, i.e., Single Sign-On Server (SSOS), Security Application Portal Server (SAPS), etc, at NTUH have been proposed. The integration of the HEIP and HIS at NTUH was also addressed in [1] initially.

As indicated above, developing an updated HIS in NTUH and eventually replacing the legacy one is a must. In addition, the newly developed system should be under controlled by NTUH delegates and engineers. The SSOS is essential to improve the CRM quality at NTUH. The tasks have carried out since December 2003. At beginning, NTUH is focusing on redesign and restructure the Outpatient Information

System in HIS with the HEIP SSOS integration.

In the following sections of the paper, we first elaborate on the single sign-on solution and the outcomes of the OIS/HIS. Secondly, we introduce value added CRM applications; an overall architecture of the integrated HEIP, HIS infrastructure is provided. Detailed descriptions of communication mechanisms as well as protocol stacks are illustrated. The paper concludes in Section 5 with a summary of our work and a discussion of our future challenges at NTUH.

II. ACHIEVEMENTS

A. Single Sign-On Solution

The concept and the necessity of Signal Sign-On scenario have been addressed. It definitely improves the quality of CRM. Users can login HEIP environment from NTUH Intranet, as indicated in Figure 1 (Portal page), and pass the firewall as well as the proxy server to the Single Sign-On Server (SSOS) at NTUH. The web-based user environment is adopted.

Fig. 1. Portal page of NTUH HIS

Currently, the implementations of the SSOS contain: 1) Web user Interface Server (WebUI) generates user's browsing web pages; 2) State Server (StateServer) stores the user's web session state variables for analyzing user logic and validation; 3) Authentication Web Service Server (Auth-WS) verifies user's authentication as well as authorization. During the validation, database access can be achieved by interfacing with HIS Integration Engine which will be described in the next section. The Microsoft Web Services (.NET) and HL7 encapsulated SOAP envelopes provide the protocols and communication mechanism among the entities depicted above [4].

In Figure 1, the applications enclosed in the rectangular, e.g., RIS, PACS, Reporting System and Core File Folder, have enabled with the Single Sign-On Solution. After users log in, they can access all systems without further validation. For example, users can click PACS and enter into the home page of the PACS system. Therefore, the HEIP Single Sign-On Solution in NTUH has linked two communication mechanisms: 1) the front-end integration, i.e., one system's

web server to invoke another system's web server, subsequently integrate two or more systems (or applications) together; 2) the middleware communication integration, i.e., .NET Web Services links internal HEIP SSOS entities as well as the external HIS Integration Engine, eventually connects to the HIS databases.

B. HIS Integration Engine & Outpatient Information System

The 4-tier architecture of NTUH HIS is described clearly in [3]. In the paper, there are two diagrams show the HL7 Framework and the HIS architecture respectively. The HL7 Framework is the Integration Engine [8] of the HIS architecture. It supports message management, routing, mapping, and database access. Detailed information about the processing of each message is also automatically logged by the Engine. Moreover, the Engine glues the medical systems (or applications) together.

Currently, the whole HIS architecture is committed to Microsoft technologies: .NET platform incorporates at HIS core as well as its ancillary systems with the invocation (method call) expressed using HL7 embedded XML format called SOAP. The newly developed OIS is implemented under the architecture and has entered full operations on 1/2/2006.

Based on the Middleware Technologies, Service-Oriented Architecture (SOA), the HIS Integration Engine is easy to deploy and offers an almost immediate return on investment. Its virtually unlimited scalability provides a low cost and compatibility with future system upgrades or changes. In addition, the HIS is ideal for heterogeneous, distributed, high-traffic environments; helping NTUH dramatically reduces operational costs while improving Quality of Services.

Theoretically, Microsoft .NET (Web Services) presents a perfect world. However, as NTUH begins to implement HIS, we often find that service de-coupling and communication between distributed services are very difficult to accomplish. The problem lies in the way Web Service Container is implemented. Most components govern, execute, orchestrate and connect different services use legacy centralized solutions that initiate communications and pass the data among them.

To increase the performance of the NTUH HIS, a cluster of identical servers, at tiers 3&4 respectively, are deployed and dispatched dynamically by introducing Layer 4 Switches. All the servers are configured running under load balancing as well as failover modes to ensure the system's availability and concurrency. The firewalls are also installed to enhance the security of the architecture.

III. VALUE ADDED CRM

In general, NTUH provides fundamental services for not only patients' healthcare usage, but faculties, staffs and medical students' educational, administrative environment establishing. They are the customers of Hospital Enterprise

Information Portal (HEIP) at NTUH. The quality of CRM was discussed in [1] including on-Line healthcare data retrieval and 3-in-1 portal. In here, we introduce additional CRM enhancements that are taking place in recent years.

A. e-Learning and Remote Consultation & Diagnosis (RCD)

The distributed, middleware-based RCD prototype was designed and implemented in 1998 [2]. RCD enables joint collaboration between pathologists, radiologists, or physicians while they are at distant geographical locations. The applications support real-time patients' data, image files, and audio, video annotation exchanges between two parties. Obviously, the applications can be used for e-Learning as well.

As the research and development extend, we will continue to incorporate the latest advances in computer, communication technologies into the applications, e.g., SIP (Session Initiation Protocol) for wireless/wired connectivity, Time-Based Media data via Java Media Framework (JMF) for real-time multimedia data exchanging, as well as DICOM (Digital Imaging and Communications in Medicine) server & DICOM viewer wrapping. We ensure that e-Learning and RCD provide the long-term, comprehensive solutions for today and tomorrow's electronic, healthcare educational needs at NTUH.

B. on-Line Vaccination Services

Vaccines not only prevent diseases for people who received them, but also protect those who contact with unvaccinated individuals. There is a vaccine program offered to children in Taiwan. Normally, the vaccines are taken between the ages of new-born to 2.5 years old approximately.

Today, there is no centralized vaccination system (or services) integrated with local vaccine providers. In other words, the Taiwan children's vaccination program is not registered anywhere, except on a child's health journal or a local clinic or hospital where the child received the vaccines. Therefore, to establish a unified Web-based, on-Line service for accessing individual vaccination records everywhere in Taiwan is necessary.

The research and investigation have been conducted in Sweden [6]. Definitely, we can incorporate and follow the approaches accordingly and deploy it into Taiwan's on-Line Vaccination Services.

C. on-Line Emergency Services

The Emergency Services are essential issues in our daily lives and communities. The first minutes after an accident occurred are often very critical and can make huge differences between life and death.

A wireless/wired Middle-based Emergency Services prototype has been designed and implemented [7]. The prototype enhances the communication possibilities not only to simplify the understanding of an accident situation at an emergency center, but to deliver first-aid instructions via

Time-Based media at the site. The underneath technologies, including: SIP, JMF, RTP (Real-time Transport Protocol), JDBC (Java Database Connectivity), as well as Java implementation are deployed.

As the research and development extend, we can integrate the services with 911dispatch center in Taiwan via Internet as well as WLAN.

IV. HEIP-HIS INFRASTRUCTURE

A. Architectures and Communication Frameworks

The next generation of HEIP-HIS infrastructure is based on a three-tier architecture that logically separates the media transport, call control, protocols and service layers within the infrastructure. This enables NTUH service providers to address individual customer needs by designing solutions independently at each tier.

Tier one is the media-processing layer that consists of media gateways accommodate traffic from a variety of access media, including wired, wireless, narrowband and broadband, etc. Tier two bridges different signaling and call control protocols, enabling service providers to integrate traffic from networks using disparate protocols. Tier three focuses on service creation. The infrastructure provides an open environment for the interconnection of HEIP-HIS servers that enable rapid service customization and deployment. The 3-tier distributed framework, HIS servers as well as HEIP value added CRM are shown in Figure 2. In the diagram, the detailed HEIP-HIS interoperable components and their integration protocol stacks are depicted.

Therefore, the new world of communication interconnects with HEIP-HIS services as well as customers, partners using disparate protocols, wireless, wired connectivity, in Taiwan and around the world.

B. Communication Approaches

The integrated wireless/wired HEIP-HIS infrastructure has become a fully connected information space. Initially, SIP adds the required capability of component discovery, session duration, and control over different transport mediums, e.g.,
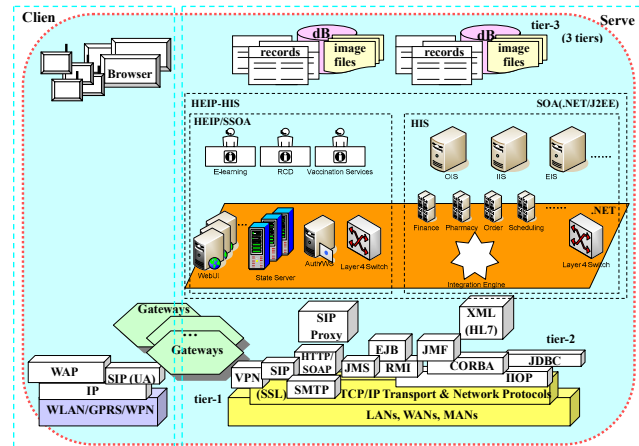

Fig. 2. HEIP-HIS Wireless/Wired Infrastructure

LAN, WLAN, Bluetooth, etc. Moreover, SOAP with HL7 is a lightweight protocol for customizable messages exchange in the environment. SIP and SOAP are both ideal for the decentralized, distributed HEIP-HIS infrastructure where many components collaborate to provide services.

The HIS has committed to Microsoft .NET architecture. On the other hand, the preliminary value added CRM applications described above have mainly deployed under different SOA techniques, e.g., CORBA (Common Object Request Broker Architecture), RMI (Remote Method Invocation) or J2EE (Java 2 Platform Enterprise Edition) over heterogeneous platforms. Because Net's SOAP capabilities do allow components on other platforms to exchange data messages with .NET components, integrating HEIP and HIS using customized HL7/SOAP should not generate any hurdler. The message exchanges can be carried out through HTTP, SMTP, SOAP-RPC, Message Queues (Java Message Service), or other loosely coupled
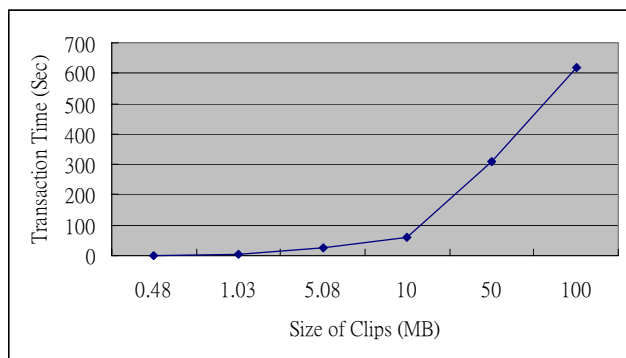

Fig. 3. Performance Evaluation of Clips Transmission over WLAN

communication mechanisms over the infrastructure.

An experimental framework covering the wireless HEIP side between two peers has been analyzed. The underneath technologies include: 1) SIP for peers' connectivity in a WLAN; 2) after the connection established successfully, clips with audio, video features were transmitted between the peers via JMF RTP; 3) the performance evaluation results were collected over the WLAN shown in Figure 3. Due to the quietness of the WLAN, there is little variance indicated in the data. Moreover, to transmit a 50 MB clip over the WLAN, in average, needs 300 seconds, i.e., 5 minutes, approximately.

V. CONCLUSION & DISCUSSION

The NTUH HIS is an innovation designed to address the continuously changing and demanding nature of today's HIS in Taiwan. In addition, it presents a solution to perform challenges imposed by heavy messaging traffic that is threatening the viability of Web-Services (.NET) implementations. The HIS Integration Engine enables the bridging between applications and back-end databases. The Engine provides clear interfaces and subsystems. The design is compatible with commercial HIS products [8]. As a result, capital expenditures are controlled and the return on

investment is shorter. Moreover, the HEIP Single Sign-On solution lets the syndication services access back-end systems without requiring user authentication each time.

The wireless/wired HEIP-HIS infrastructure is proposed. It is not another new strategy, but rather a new paradigm for the delivery of healthcare services that requires process reengineering, cultural changes, as well as organizational changes at NTUH.

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