

Building a generic architecture for medical information exchange among healthcare providers

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Abstract

Due to the inability to exchange clinical information among hospitals, continuity of care cannot be maintained and a tremendous amount of medical resource has been wasted. This paper describes an architecture that would facilitate exchange of clinical information among heterogeneous hospital information systems. It is dubbed 'Medical Information Exchange Center' or MIEC as part of a six-year Health Information Network Project hosted by the Department of Health. MIEC was designed so that it is innovative yet technically feasible today. It is convenient for authorized users yet secure enough so people can trust and has minimal impact to participated hospitals. Authorized users will be able to access information through two web-based interfaces directed to physician and non-physician users respectively. Hospitals are connected through a virtual private network to exchange patient information and users need to obtain a private key from the certificate authority in order to securely connect to MIEC. A pilot project was conducted to demonstrate the feasibility of this architecture and the problems encountered were discussed. © 2001 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

1.1. Background

Ever since 1996, most of the 22 million

people in Taiwan have been enjoying comprehensive medical care coverage paid entirely by the Bureau of National Health Insurance (NHI). More than 33 billion dollars were spent on 1.1 billion outpatient [1] visits and 10 million inpatient [2] stays. Although most of the 19 000 or so clinics and hospitals were reimbursed directly by NHI

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through electronic claim submission, none of the patient information can be transferred electronically among different hospitals. When a patient needs to get access to his/her own medical record, laborious application processes have to be completed to obtain only part of the photocopies. It is estimated that more than 20% of the medication prescribed were redundant because patients tend to visit several hospitals for the same medical problem. Even more tests and exams were repetitive because of this so-called 'doctor shopping' behavior. Most of the medical resources wasted among different hospitals could have been saved if hospitals can somehow exchange patient information during their hospital visits.

1.2. Health Information Network 2.0

In 1987, Taiwan government initiated a project, coded National Health Information Network (HIN), to establish a nationwide infrastructure for health information exchange. Since then, an information network has been built, which consisted of three regional centers and a backbone with TCP/IP over frame-relay that connects to most of the public hospitals. With a total of 660 million dollars spent, the HIN was however a partial success. It supported, successfully, for public health administration ranging from hospital regulation to cancer registry, but only 13% of all health insurance claims were done online through the HIN and almost no function for patient referrals. Therefore a new six-year project, HIN 2.0 was recently launched by the Department of Health to reconstruct the infrastructure and to enhance function originally proposed. New focuses includes virtual private network (VPN) with an emphasis on security and privacy protection, life-long electronic health records, 24-h access to records, health insurance smart card, establishment of

a certificate authority for all health professionals, public access to online information and a national virtual library for health. Over the past two years of planning stage, building a national Medical Information Exchange Center (MIEC) for inter-hospital clinical information exchange was one of the major pilot projects.

1.3. A pilot MIEC project

Funded by the Department of Health, MIEC [3,4] attempts to be an infrastructure within HIN 2.0 that provides mechanisms for healthcare providers to exchange patient-specific clinical information [5,6] securely [7], efficiently and accurately.

Major goals for the MIEC project are (1) to support continuity of care through exchange of clinical information [8], (2) to reduce redundant examinations, tests and medications and, (3) to improve quality of care. Most people visited at least several different hospitals in a lifetime, not to mention that 'doctor-shopping' in Taiwan is fairly common. But without a mechanism to exchange information among hospitals, continuity of care cannot be maintained when a patient starts to visit different hospitals. The inability to review patients' previous medical history in other hospitals also generates redundant exams/tests and medications that can be a great burden to the NHI and also compromise quality of care.

2. The MIEC architecture

It is expected that any attempt to exchange clinical information from various healthcare organizations will be impeded by technical, confidential [9] and political issues. This project sets the following principles to mitigate these problems:

1. It is innovative yet technically feasible today.
2. It must be secure enough so people can entrust their data.
3. Implementing MIEC must have minimal impact to the original hospital information system.
4. It must provide convenient access for authorized users.

Authorized users will be able to access information through two web-based [10–12] interfaces directed to physician and non-physician users respectively. Hospitals are connected through a VPN to exchange patient information and users need to obtain a private key from the certificate authority in order to securely connect to MIEC.

The MIEC architecture can be divided into two main compartments: central and peripheral ones (Fig. 1). The central compartment consists of five servers and two interfaces.

The servers are web server, index server, audit server, access server and certificate authority server. The two interfaces are designed for physicians (physician workstation — PW) [13–15] and patients (patient centered retrieval—PCR) [16–20] respectively. The peripheral compartment resides in each participating hospital where one resource server (RS) and a gateway will be installed outside each hospital's own firewall. Both compartments are then linked through the internet via a VPN under HIN 2.0. Functions of the two compartments are described.

2.1. Central compartment

The central compartment of MIEC serves as a broker to retrieve the clinical data from the RS in the peripheral compartment. For security and political reason, none of the patient clinical data would be kept in our

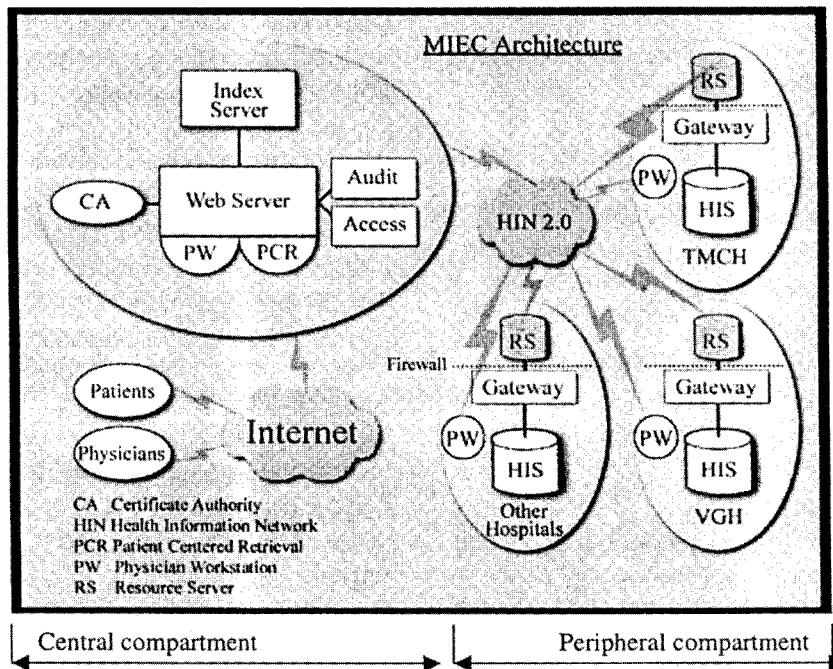


Fig. 1. Most of the servers are located on the central compartment, the peripheral compartment consists only a resource server and a gateway.

central compartment. It only stores basic patient information and links to the RS in hospitals where each patient's clinical data was available. Once a user registered to the certificate authority server, he or she will be granted appropriate access right by the access server. A security matrix that employs data sensitivity, three-zone confidentiality models [21,22] and user's role is used to determine the access right. By using links in the Index server, this user will be able to retrieve patient data from RSs located in all relevant hospitals through a web-based interface hosted by the web server. There are two interfaces designed for patients and physicians respectively. The PCR interface focuses on provision of user's own medical information in an easy-to-understand format. Most medical terms are displayed bilingually in Chinese and English, and are all linked to detail illustrations on the internet. The PW interface is designed for physicians to quickly and easily review a patient's past medical history. Color-coded laboratory results are listed in chronological order through the web browser as well as images and reports if available. All the access history will be logged by the audit server to the last detail to guarantee accountability.

2.2. Peripheral compartment

The peripheral compartment is designed to physically locate in each participating hospitals. This compartment consists of a gateway that pulls data from a hospital's HIS and transforms the data into the format recognized by the RS. The gateway is a program that should be customized according to each hospital's native database. It can be tailored to each hospital's policy of data sharing. For example, interval of updates, type of media, type of exams/tests can all be determined by the hospital in the way that impacts least to

its HIS. The RS, however, resides on a separate computer outside of each hospital's fire-wall. It accepts data sent by the gateway program and stores it in a relational database format while it updates the index server back in the central compartment whenever necessary. Generally, the gateway can read from and write to the RS, while the central compartment performs only read action. This is to make sure that the hospital will have the utmost control over their patient data.

3. Preliminary test

In order to test the feasibility of exchanging information between hospitals with heterogeneous HIS with MIEC, two hospitals with totally different information systems (one mainframe-based and the other client-server) were chosen in our pilot study. These two hospitals serve more than 10 000 outpatient visits a day. Primitive gateway programs that retrieve medical exams/tests data were implemented in both hospitals and only patients that visited both hospitals in the last six months were selected from the HIS databases. Since the mainframe uses a hierarchical database to store patient data (rather than the relational structure in the RS), it was more complicated to implement the gateway program than that in the client-server site. It was also much harder to run this gateway program without affecting the performance of the original HIS because of the computing resource needed in this process. On the other hand, the gateway program was just a little more than several SQL queries to retrieve data from the relational database in the client-server site.

The inconsistency of coding scheme in laboratory tests and exams also posed a major problem to data exchange. We had to develop a unified coding scheme for all the

exams/tests based on LOINC [23] to accommodate codes from both sides. We expect to have more coding issues when more hospitals are involved.

4. Discussion

The MIEC project represents the first step towards clinical information exchange among different hospitals. It provides architecture that proved to be technically feasible and practical today. But there are still many obstacles to be overcome. First, we encountered the recurrent theme of coding problem. Although the NHI have a set of standard coding for all items it reimburses, the codes are often an aggregation of a set of tests or reused for items that cost the same. For example, a CBC/DC (complete blood count/differential count) panel may use only one code even though it consists of more than ten different laboratory values. We are developing a code set called UCOMET (Unified Code of Medical Examination Taiwan) that accommodates LOINC from the HL7 group for MIEC that can hopefully solve this problem. Secondly, the public may not be comfortable with their personal medical data transferred on the internet. We still have to explain the certificate authority and VPN concepts repeatedly to the public to ensure their acceptance of MIEC, although there are now more than four million internet users in Taiwan. In 2001, a healthcare IC card will be issued to all the insured that can be used to store a private key. This may speed up the development of the PKI (public key infrastructure) that supports the certificate authority mechanism. Thirdly, hospitals may not want to share their data with patients, not to mention competing hospitals, in a competitive healthcare environment like Taiwan. Fortunately, the Health Ministry has announced that all the content in a medical record belongs

to the patient, not to the hospital. Therefore a hospital has to share these data with the patient if so requested, in paper or electronic form. Although hospitals may compete for a same group of patients and thus want to keep all information from their competitors, inability to share patient information to other hospitals may also be regarded as a major disadvantage and invite rejection from patients since everyone is free to change their own care provider any time in the current NHI policy.

In addition to the issues mentioned above, there are still problems that we may or may not anticipate in the future. But given the rapid growing healthcare cost and the impending change of the reimburse models from fee-for-service to integrated delivery system [24]. We believe that an efficient mechanism for medical information exchange among hospitals is one of the key elements to ensure better quality of care with less cost.

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