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De-Centralized Network System For Sharing Electronic Medical Records

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Abstract

Collaboration among medical specialists is necessary. Some regional medical collaboration systems have been developed using centralized models. The centralized model network determines collaboration within the network and cost too much. Therefore, we have preliminary developed a de-centralized medical collaboration system to overcome this barrier to collaboration as sustainable network. This model has some capability to establish sustainable medical network.

Keywords:

de-centralized communication, open source software, electronic medical record, internet, P2P

Introduction

Medical professionals collaborate via referral letters. There are some systems that enable the sharing of electronic medical records (EMR), within a wide area network, using a centralized model[1-5]. However, such models limit the communication and collaboration of EMR to within the network (Figure 1). If we wish to refer a patient to another doctor in such a model, we must confirm whether the doctor belongs to the network or not. Therefore, the centralized model network encloses medical specialist within its network and constitutes a barrier to medical collaboration. Consequently, the centralized model does not match real medical relationships.

Therefore, we preliminary developed a medical-record-sharing system using a de-centralized network to construct de-centralized network which connect every hospital seamlessly (Figure 2).

The aim of this project was to develop collaboration software that seamlessly communicates electronic medical records to other professionals using a de-centralized network.

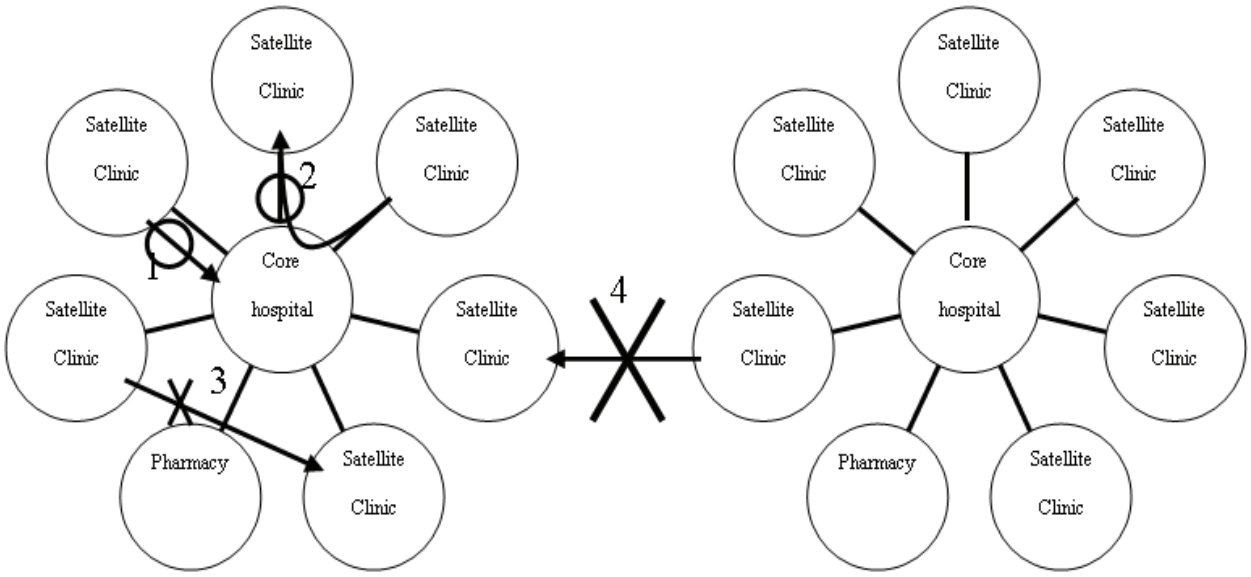

Figure 1 - Typical centralized network model. In this model, a satellite participant can refer a patient from the satellite to the central hospital (arrow 1) or to another satellite via the central hospital (arrow 2). However, a participant cannot refer a patient to another satellite directly, or to another network (arrow 4)

Methods

The system was separated into three modules: the medical referral letter editor, peer-to-peer (P2P) communication, and message management modules. We adopted Java as the development language and developed it using Sun Java 2 Standard Edition Software Development Kit (J2SE SDK) 1.4.2[6]. We used JXTA 2.1[7] as the P2P framework to construct de-centralized network, Eclipse 3.2.1[8] as the integrated development environment (IDE), and Concurrent Versions System (CVS) [9] to administer the source code. The CVS repository is placed on Sourceforge.jp and can be viewed at http://cvs.sourceforge.jp/cgi-bin/viewcvs.cgi/mega-net/.

Medical referral letter editor module

The patient referral letter implements a graphical user interface (GUI) to edit the message. The information in each message is stored as a Java instance and contains the patient's name, birthday, sex, age, diseases, clinical course, past history, family history, medications taken, and notes. After editing the message, it is sent to a medical specialist by the P2P communication module and stored by the message management module.

P2P communication module

For the implementation of this module, refer to the programmer's guide for JXTA[10]. This module includes the following features:

- Create or join PeerGroup with secure authentication.
- Extend PeerAdvertisement with hospital (institute) name, address, doctor's name, doctor's speciality, telephone number, and FAX.
- Publish and discover the extended PeerAdvertisement in real time.
- Connect peer to peer via an encrypted pipe.

The peer discovery algorithm is distributed hash table model implemented with JXTA. A PeerAdvertisement is generated when instantiating a group on a peer, and contains all the necessary parameters, including the participant's medical information in XML format. PeerAdvertisement propagates within PeerGroup, which can connect segments within a secure network cloud, and requires password authentication to join.

Each peer propagates its organization information and doctor's information within this securely protected PeerGroup to be identified. The participant sends an electronic referral letter to the other who could join this network with this authentication, on demand. The PeerGroup provides an encrypted pipe for peer-to-peer connections and sends a ciphered message with patient information using the TLS 1.0 protocol[11] to provide security against Internet sniffing.

When a message is received, this module decrypts the message and stores it on a local hard disk using the message management module.

Message management module

Each electronic medical referral letter is serialised as a Java instance. The serialised instance is saved and loaded on a local disk via a Java stream. This module stores messages that are sent and received via the P2P communication module. The messages are listed in a table and can be viewed as three windows, similar to the layout in MS-OutLook. This module also manages other items to extended PeerAdvertisement described before.

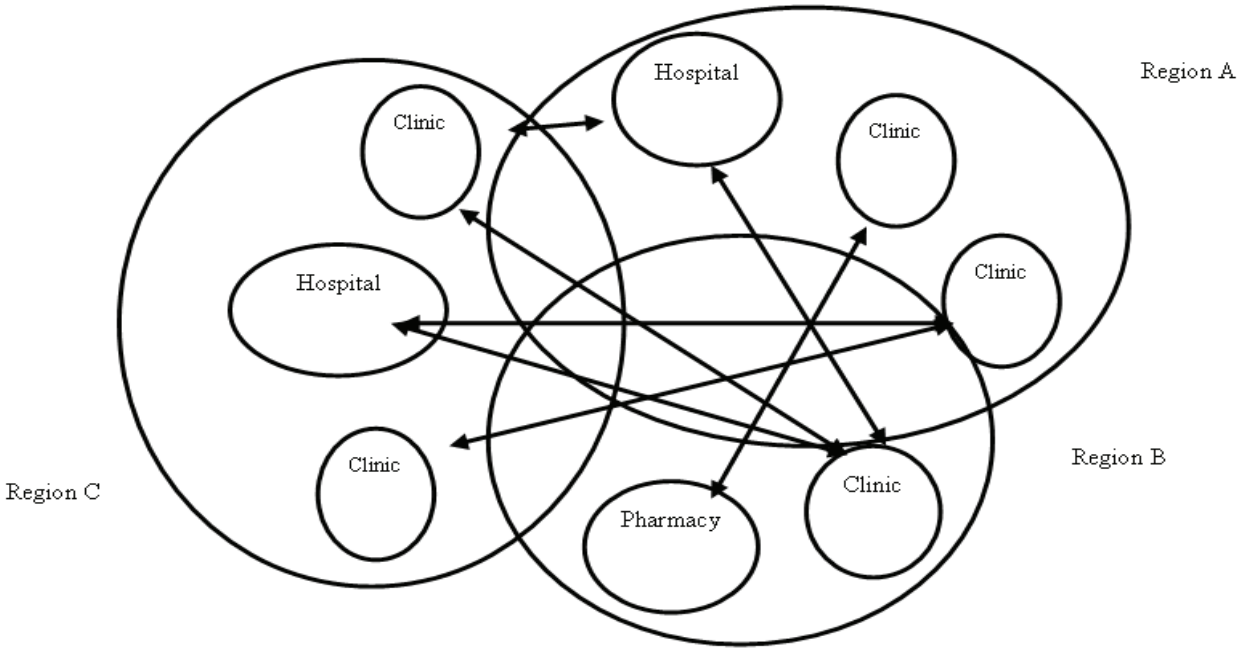

Figure 2 - De-centralized network model. In this model, a participant can make seamless referrals to other participants beyond the region

Results

Our system can successfully transfer encrypted electronic medical referral letters to doctors via a P2P network.

It takes about five minutes to configure this system for use after downloading it. Since there is no server, a client only needs to configure for his / her network. The configuration needs the P2P setting and user information. The only cost to join this network is that of downloading it.

Writing a referral letter

This system finds peers automatically. Information on peers can be viewed in a list window. The list shows the doctor's name, specialty, and organization name. The recipient of the letter can be chosen from this list.

The user can edit a referral letter with a GUI. After editing it, the message is sent to the selected peer instantly and saved on a local hard disk.

Message management

This system receives messages automatically. Messages are saved in two folders: 'sent' and 'received'. The list of messages can be viewed by GUI.

Discussion

As this project is a work in progress, many problems remain to be solved. Nevertheless, this system offers tremendous benefits that can make up for these problems. This paper discusses these problems and invites interested parties to join the project.

The most significant problem in setting up a health care network is that of interconnecting the centres within the network[12]. Each physician should be able to determine which medical specialist to collaborate with, rather than having this decided for him or her by the network architecture. In our de-centralized model, medical professionals can introduce patients to specialists outside the regional network system, as they deem appropriate.

Network model	Development	Maintenance (Server)	Maintenance (Participant)
De-centralized	$60,000	$0	$0
Centralized	$2,000,000	>$100,000/year	>$1,000/year

Table 1 - Cost of the network (Estimate based on other medical record network services which developed by the fund of national funds in our country.)

However, this system has critical problem that cannot send message to off-line participant, although in centralized system, server stores the message for off-line participant. To resolve this problem, we are now refactoring this system for off-line participant by queuing message on local until the participant is on-line to be send message.

In addition, since this system runs on Java VM, it does not depend on a specific operating system (OS). Therefore, this system has few restrictions, not only in terms of medical use, but also in terms of the computer environment.

One remarkable advantage of this system is its total cost (Table 1). In Santa Barbara County, US, P2P based medical system project also reported that it succeeded to reduce total cost of medical communication [13]. There is no cost for a network server with this system. Since we used open source products, we saved development costs. There is, in addition, no cost or fee for participants who wish to join this network. This constitutes a major advantage, as compared to other systems.

As contrast with centralized model, de-centralized network is looser combination with each information system. In general, tight information integration, which shares the same database, is easier to develop than loose one. If chronologically ordered data are needed (laboratory data centre, for example), centralized model is superior to the looser data integration[4]. Therefore, we have to develop some tight information combination interface to the other system that can apply under the open source license.

However, since our source code is open, others can adapt it to the communication module of their hospital information system. Our licence permits the use of our source code in proprietary software.

This system is robust against malicious Internet attack because the target is so widely distributed; this means that an attacker cannot jeopardize the entire system. Even if an attacker cracks the system of one participant, the other participants can still communicate with each other. While it has a lot of merits for medical specialist that EMRs are distributed and available like notorious file sharing systems, patient privacy issue does not allow it. Therefore, we decided security policy that peers can only send EMR to the associated doctor to refer a patient and the documented agreement of patient for transfer is necessary to transfer his / her record, and cannot issue query to the other peer to get unrelated EMRs. Under this policy, the risk of information leakage should be minimal because each participant only stores information on his / her own related patients.

This method does not conflict with inter-network communication, such as IHE-IDX. Peer-to-peer communication system can easily be adapted to organization-to-organization communication.

Although this system has some merits than the other system, legal issues has raised on P2P system. In Japan, P2P file sharing system named Winny caused many security issues that leak significant confidential matters on many personals, companies, and government (such as military matter). The author is accused in a court, whether to develop P2P software is guilt or not. This project is faced in the trouble that we cannot continue our development until this legal issues is clear.

Moreover this system has many technical issues on security and the other field, but we think it is only the technical issue that is able to be resolve. Therefore, we are trying to reconstruct this application over web-based framework, which can disclose electronic medical record to the consumer or the other healthcare provider with strict security for fair use.

Conclusion

We have preliminary developed a de-centralized collaboration system that can transfer electronic medical information seamlessly. As compared to other systems, our system has fewer restrictions, is inexpensive, and can be used to construct a robust network. Furthermore, our open source software has the potential to evolve, which will allow any remaining problems to be overcome in the near future. This system has the capability to enrich medical practice but has been faced to the legal issue.

Acknowledgement

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References

[1] Takeda H, Matsumura Y, Kuwata S *et al.* Architecture for networked electronic patient record systems. Int J Med Inf 2000; 60: 161-7.
[2] Bruun-Rasmussen M, Bernstein K & Chronaki C. Collaboration--a new IT-service in the next generation of regional health care networks. Int J Med Inf 2003; 70: 205-14.
[3] Altman JE. PKI Security for JXTA Overlay Network; http://www.jxta.org/docs/pki-security-for-jxta.pdf
[4] Hung K & Zhang YT. Implementation of a WAP-based telemedicine system for patient monitoring. IEEE Trans Inf Technol Biomed 2003; 7: 101-7.
[5] Lampsas P, Vidalis I, Papanikolaou C & Vagelatos A. Implementation and integration of regional health care data networks in the Hellenic National Health Service. J Med Internet Res 2002; 4: E20.
[6] Java[tm] 2 SDK, Standard Edition Version 1.4.2;in http://java.sun.com/j2se/1.4.2/download.html
[7] JXTA 2.1; in http://download.jxta.org/archive/jxta2.1_bin.zip
[8] Eclipse 3.2.1; in http://www.eclipse.org/downloads/
[9] [9]Price D. CVS;in http://www.cvshome.org/
[10] Project JXTA v2.0: Java Programmer's Guide; http://www.jxta.org/docs/JxtaProgGuide_v2.pdf
[11] Dierks T & Allen C. The TLS protocol Version 1.0; in RFC 2246 http://www.ietf.org/rfc/rfc2246.txt
[12] Ruotsalainen P. A cross-platform model for secure Electronic Health Record communication. Int J Med Inf 2004; 73: 291-5.
[13] Czerwinski AA. Bringing Everyone's Information Closer to the Point Of Care. In: Annual healthcare information and management systems society conference and exhibition; 2002.

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