A Collaborative Workspace for Telemedicine System

Augustine Tsai, Hung-Wen Tung
Institute for Information Industry, Taiwan
Email: {atsai, hwtung}@iii.org.tw

Abstract

This paper is based on the previous research on collaborative session and presents the design of a collaborative workspace in a telemedicine system. In this collaborative workspace, medical images, reports, device data are being transferred using the standard for medical image exchange. We use an open instant messaging protocol to conduct the remote consulting activity. With this collaborative workspace, multiple physicians located at different sites can examine one patient at the same time. With image annotation and structured report being transferred, physicians can exchange their opinions and findings with each other. Specialized or experienced physician can provide clinical guidelines to the bed-site physician. Device data provides real time information about the patient. With this system, diagnostic health care service can be provided remotely to areas lacking sufficient medical resource.

1. Introduction

With the growth of Internet and the development of hardware and software technology, applying IT to medical care has been one of the important issues in current days. Many medical devices have been integrated with computer systems to analysis the data. Standards for medical information are being established to facilitate the exchange of information. When facing the problem of unbalanced medical resources between rural or less-developed areas or cities and developed ones, how to provide essential health care service to those rural and less-developed areas drives the idea of using a telemedicine system to deliver the services from remote site.

To this end, we utilize the idea of collaborative workspace [1] when designing a remote consulting system. In this system, multiple health care providers located in different sites could work together to give diagnostics to the patients in rural or less-developed areas. The underlying communication between users of this system is based on an instant messaging protocol. The integration of medical resources, including medical records, images, mechanic devices, and guidelines, makes the multiple health care providers can examine the same patient information concurrently. The rest of the paper is divided as follows: Section 2 introduces the instant messaging adopted by our system. Section 3 presents the standards for medical images and reports that our system followed. Section 4 presents the design of the collaborative workspace. In Section 5, we develop the conclusions of our work.

2. Instant Messaging

The use of instant messaging (IM) has become popular in these years. There are several popular consumer IM services, like AIM, ICQ, MSN and Yahoo, exist today. The Internet Engineering Task Force (IETF) has formalized the core XML streaming protocol as an approved instant messaging and presence technology under the name of Extensible Messaging and Presence Protocol (XMPP), and the XMPP specification have been published as RFC 3920 and RFC 3921 [2] [3].

In the security aspect, unlike some legacy protocols, like POP3 and SMTP, which do not provide a way to choose nodal relationships, i.e. permission to send or receive to or from a node. The presence notion in the XMPP protocol does not allow nodes who have not established a mutual agreement to send or receive messages and/or streams of data. Figure 1 shows a simple message in XMPP format. There are previous works utilizing IM in telemedicine system [7], mostly in an information transfer aspect. In this paper, we utilize IM to put some add-on features in our collaborative workspace. For organizations wishing to ensure that all data are encrypted, they can configure the collaborative session to ensure encryption of message transfers.

```
<message to="JamesBond@server1/JETI" id="JETI_0" type="chat">
        <thread>22b0f010b4a9782fc</thread>
        <body>hello</body>
        <x xmlns="jabber:x:event">
                <composing/>
        </x>
        <html xmlns="http://www.w3.org/1999/xhtml">
                <body>
                        <span style="font-family: Arial; background-color:
                </body>
        </html>
</message>
```

Figure 1 An example of XMPP message.

3. Standards for Medical Images and Reports

The Digital Imaging and Communications in Medicine (DICOM) was created by the national Electrical Manufactures Association (NMEA) [4], and is now commonly used for the transfer and storage of medical images. For transmission and storage of clinical documents, the structured report (SR) standard provides capability to link text and other data to particular images or waveforms and to store the coordinates of finding. A

SR document not only describes the specific features contained in images or waveforms but can also refer to any number of images or waveforms. Therefore, SR bridges the traditional gap between imaging system and information system [8].

The medical images and documents used in our system are compatible with the DICOM image and SR document standards, therefore the system can fit into any hospital that conforms to these standards. We also use the DICOM standard to facilitate the storage and retrieval of medical image and structured report at remote sites. In the security aspect, the data transferred can just be encrypted using standard mechanisms and utilities.

4. Collaborative Workspace

In our previous works [1], we have discussed the concept of session management in a collaborative workspace. In this paper, we present the design of our system to realize the concept of session management.

Figure 2 illustrates the collaborative workspace of our telemedicine system. On the left side demonstrates the bed-site physician who is requiring consultant when he/she examines the x-ray image of the patient. So he/she login to the system and invite a remote physician who is specialized in that particular area to join the collaborative workspace the system provided. The content of the remote consultant invitation includes the patient identification, the medical image identification, etc. When remote physician accepts the invitation, he/she can retrieve the related images and records from the DICOM server using the identifications in the invitation and then enter the collaboration workspace. Therefore in collaborative workspace, both physicians see the same user interface that includes the medical record, medical images, and data from the mechanic devices connected to the patient. Both physicians then can make annotations to the medical images, and update the medical record according to the information they acquired. In this way, the patient could receive diagnosis from a specialist that is located on the remote site. The following discusses the detail of this design.

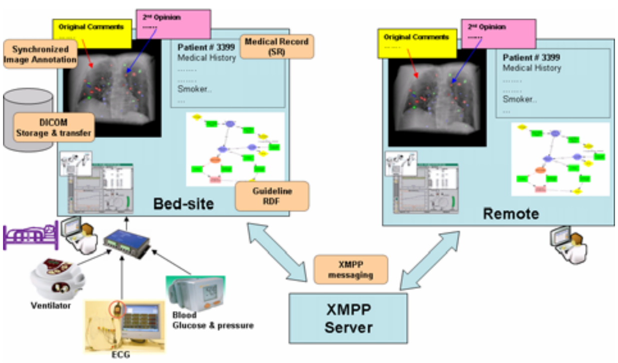

Figure 2 Collaborative workspace.

4.1. Session Protocols in Collaborative Workspace

Figure 3 illustrates the instant message processing in the collaborative workspace. All communication underlying the workspace is based on the XMPP protocol. The XMPP protocol used includes the instant messaging for remote consultant invitation, image annotation, findings, clinical guidelines, and device data. We design a message processor plug-in to the instant messeng client. Each message transferred to the collaborative workspace is parsed by the message processor and categorized according to the message tags.

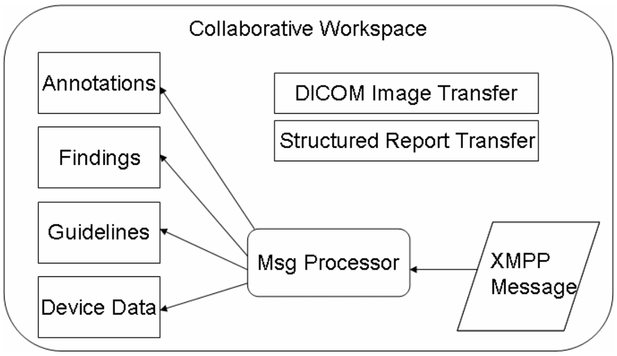

Figure 3 Instant message processing in collaborative workspace.

We use the synchronized annotation function to describe how we design the session protocols in collaborative workspace. In initial phase, bed-site physician retrieve the DICOM image from the server in the hospital using the retrieval command defined in the DICOM standard. And then he/she invites the remote physician to join his/her collaborative workspace. When the remote physician accepts the invitation and joins the collaborative workspace, the patient’s medical image and document are retrieved from the DICOM server by the patient identification provided in the invitation message. Figure 4 demonstrates the remote consulting user interface when the physician joins the collaborative workspace.

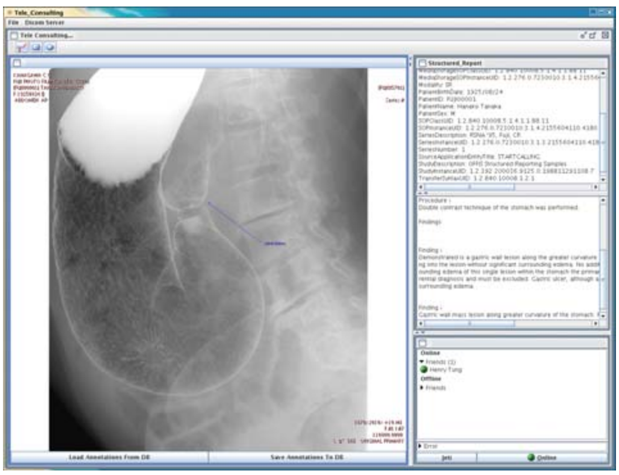

Figure 4 Remote Consulting User Interface

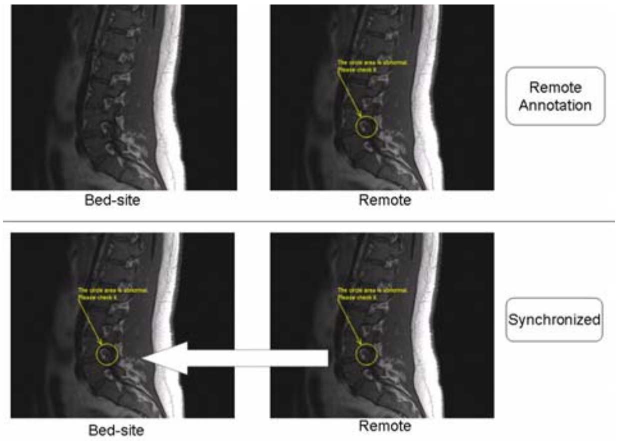

Figure 5 Synchronizing Image Annotation.

As figure 5 shows, when the remote physician finds that something's wrong within the DICOM image, he/she can use the tool provided by the workspace to annotate on the image. When remote physician submits the annotation, the workspace would present it to the screen of bed-site physician.

To transfer such an annotation to another physician, the data representation of the annotation is formatted using XML and is inserted to the body of XMPP message. As shown is figure 6, when the system parses the annotation tag in the body of the XMPP message, it will automatically process this message as an annotation instead of normal chat message. And the receiving site will trigger the drawing utility to re-produce the annotation on the screen to synchronize with remote-site, which is the result in the lower part of figure 5. The receiving site can also make a counter-comment of the image as another annotation and synchronize it to the remote physician.

```
<message to="JamesBond@server1/JETI" id="JETI_0" type="chat">
        <thread>22b0f010b4a9782fc</thread>
        <body>
                <annotation>
                        <point1><x>161.42</x><y>143.64</y></point1>
                        <point2><x>81.40</x><y>94.39</y></point2>
                        <text>This area seems to be the problem.</text>
                </annotation>
        </body>
        <x xmlns="jabber:x:event">
                <composing/>
        </x>
        <html xmlns="http://www.w3.org/1999/xhtml">
                <body>
                        <span style="font-family: Arial; background-color:
                </body>
        </html>
</message>
```

Figure 6 XMPP message for synchronizing annotation.

Besides annotation on images, when the bed-site physician consults the remote physician, the workspace also provides a function for remote physician to document his/her finding. When remote physician submits the findings it will be transmitted in the XMPP message format, as shown in figure 7. When the system parses the finding tag in the message, it will process the finding message into SR document and trigger the report browser in the bed-site screen to show the finding (Figure 8).

```
<message to="JamesBond@server1/JETI" id="JETI_0" type="chat">
        <thread>22b0f010b4a9782fc</thread>
        <body>
                <finding>
                        The examination demonstrates a ......
                </finding>
        </body>
        <x xmlns="jabber:x:event">
                <composing/>
        </x>
        <html xmlns="http://www.w3.org/1999/xhtml">
                <body>
                        <span style="font-family: Arial; background-col
                </body>
        </html>
</message>
```

Figure 7 XMPP message for transmitting finding.

Basic Text SR Document

Patient:	Charles Wilkins (male, #GE0514)
Completion Flag:	PARTIAL
Verification Flag:	UNVERIFIED
Content Date/Time:	2002-05-10, 16:34:56

CT Report

Request:
CT: Abdomen

History:
Patient is a 45 year old male with abnormal liver function test. Ultrasound evaluation demonstrated a 3 cm lesion in the medial aspect of the right lobe of the liver. The question was raised regarding potential hemangioma.

Procedure:
Serial imaging was obtained in the upper abdomen with the administration of oral and intravenous contrast.

Finding:
The examination demonstrates a well circumscribed 3 cm lesion present within the medial aspect of the inferior right liver lobe. Initial evaluation demonstrates lack of contrast enhancement. Subsequent imaging (not shown) demonstrated typical contrast enhancement pattern of a benign hemangioma of the liver. The remaining contrast enhancement pattern in the liver is normal. There is normal appearance of the adrenal glands, spleen, kidneys, and pancreas. There is no evidence of liver metastasis. 3 cm nodule present in the inferior medial aspect of right liver lobe. Contrast enhancement pattern consistent with the diagnosis of hemangioma.

Best illustration of finding:
CT image

Figure 8 Structured Report Browser.

When the collaborative session is finished, either by remote or bed-site physician exiting the workspace or by network connection exceptions, the annotations and the findings are saved as a SR document and store back to the hospital server. The session can be re-built again when the bed-site physician starts the remote consulting procedure and retrieves the image and document back to the workspace.

4.2. Medical Guideline Recommendation

For patients that require complex clinical guidelines to be followed when providing the treatment, the remote physician can use the workspace to recommend a clinical guideline to the bed-site physician. Guidelines are encoded in the RDF (Resource Description Framework) format [6], and using the Protégé tool [5], guidelines could be viewed in a graphical flowchart way (Figure 8). The RDF is encoded in the body of the XMPP message with the guideline tag. Similar to the annotation and finding tag, the system trigger the guideline viewer to show the guideline to the bed-site physician. When collaborative session is finished, the guidelines could also be saved in a SR document back to the hospital server.

Figure 9 Clinical guideline

4.3. Medical Device Information

Several devices connected to the patient provide useful information when making diagnosis. Most medical devices we integrated are communicated to the bed-site computer through the RS-232 interface. In the collaborative workspace, we integrate the respirator to display the respiratory waveform, the ECG, and also the blood pressure and glucose from the connected instruments. These data are also transmitted with appropriate tags encoded in the XMPP message, making remote physician able to examine real time data from these devices.

5. Conclusion

The collaborative workspace in telemedicine system provides a media to facilitate the consulting procedure between physicians. With the workspace in the system, bed-site physician in rural or less-developed areas can consult more specialized or experienced physicians located at the remote site. Remote physician can examine the patient's medical images, medical documents, real time data from the device connected to the patient, and provide comments and findings to the bed-site physician. With the integration of clinical guideline system, remote physician can also recommend a clinical guideline to the bed-site physician.

Further development will be focused on building a knowledge base from annotations and documents generated from previous collaboration sessions. With the knowledge base, medical students or junior physicians can study previous cases and gain experience. Since this is a design form our previous works on collaborative session to a real system. In our future work, we would like to make this system works by providing it to the hospitals and evaluated by real users. We hope by the feedback from real users can help us making it a solid and sound system.

6. Acknowledgement

This research was supported by the Service Web Platform Technology Research and Development Project of Institute for Information Industry and sponsored by MOEA , ROC.

7. References

[1] A. Tsai, H.W. Tung, and S.C. Chung, "Apply Collaborative Sessions with Coordination Rules to Respiratory Care and Monitoring System", *Submitted to MIST 2006*.

[2] http://www.xmpp.org/

[3] http://www.jabber.org/

[4] DICOM, http://medical.nema.org/

[5] Protégé, http://protege.stanford.edu/

[6] http://www.w3.org/RDF/

[7] CE Chronaki, and et al., "An eHealth platform for Instant Interaction among Health Professionals," IEEE Computers in Cardiology 2003, pp.101-104, 21-24 Sept. 2003

[8] The DICOM Standard, Overview and Characteristics Whitepaper,
http://www.ringholm.de/docs/02010_en.htm