Title: CoMed: A Real-time Collaborative Medicine System

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Summary

CoMed is a prototype of a real-time collaborative medicine system that allows medical specialists to share patient records and to communicate with each other on the Internet. CoMed consists of a multimedia medical database containing relevant information about laryngeal diseases and a real-time collaboration system including a teleconferencing system, a whiteboard and a chatting system. CoMed is web-based. We adopted the object database O_2 and CORBA technologies for the multimedia medical database. Therefore, our system can provide the flexibility, extensibility and location transparency of patient databases. We developed a SeeYou Active X control for the teleconferencing system, and a Java applet for the white board and chatting system. CoMed improves the efficiency of the overall system by separating the servers on a UNIX machine and a Windows NT machine.

CoMed can be utilized for stand-alone research, for collaborative consultations among medical specialists, and for a telemedicine in participation with the patients and medical specialists. Our system can be extended easily into other types of the collaborative systems, such as collaborative distance learning, collaborative science system, etc..

CoMed: A Real-time Collaborative Medicine System

Abstract

CoMed is a prototype of a real-time collaborative medicine system that allows medical specialists to share patient records and to communicate with each other on the Internet. CoMed consists of a multimedia medical database containing relevant information about laryngeal diseases and a real-time collaboration system including a teleconferencing system, a whiteboard and a chatting system. CoMed is web-based. We adopted the object database O_2 and CORBA technologies for the multimedia medical database. Therefore, our system can provide the flexibility, extensibility and location transparency of patient databases. We developed a SeeYou Active X control for the teleconferencing system, and a Java applet for the white board and chatting system. CoMed improves the efficiency of the overall system by separating the servers on a UNIX machine and a Windows NT machine.

1. Introduction

The application of computer and communication technologies has resulted in the birth of telemedicine[1,2,3,4], generally defined as the use of computer and communication technologies to communicate health information and to provide health care services over distances. Meanwhile, the recent rapid development of collaborative computing technology urges the necessity of collaborative medicine and collaborative consultation, especially in the field of otolaryngology[5,6,7,8,9].

The real-time collaborative medicine system must support the synchronous interaction among medical specialists, and allow for real-time sharing of the patient information and for collaborative consultation. The synchronous interaction technology needs the advanced techniques found in computers.

Among many studies about telemedicine, we present briefly the following existing systems that influenced our study:

- Telemed[1]: TeleMed provides an international collaboration based on virtual patient records. The virtual patient record is a media-rich, graphical patient record utilizing data gathered from several different remote locations. TeleMed is implemented by using Java and CORBA technologies.
- Medfast[2]: The US Department of Defense Advanced Research Projects Agency (DARPA), funded the telesurgery project named MedFast, or Medical Forward-Area Surgical Telepresence. The concept is to operate the surgical unit in areas of conflict,

accidents, or natural disasters. The surgeon, from a safe distance, controls the remote operation through force-feedback devices such as surgical instruments. The system could also use specialized aircraft and satellite systems.

- MedNet[3]: MedNet and its predecessor, NeuroNet, were established at the University of Pittsburgh. This system is based on the Ethernet, and provides real-time monitoring and multiparty consultation in the field of brain surgery. The inter-operative monitoring places a real-time control loop in front of the patients and surgeon, to warn the surgeon when the patient's nervous system is incurring damage.
- Bermed[4]: Bermed was developed at the German Heart Institute and the Rudolf Virchow University Hospital. Bermed logically integrates distributed, multimedia patient data and gives authorized physicians transparent access to it through a single workstation. The system provides asynchronous remote access to the data and synchronous desktop conferencing between physicians connected by ATM and ISDN wide-area networks.

The computer-based, collaborative medicine allows medical specialists to do the teleconsultation among themselves, or with patients, and finally allows medical specialists to supply high-quality health-care services.

Our system is based on the multimedia patient record. Otolaryngology gathers information about the five, special human sensory organs used to communicate with the environment. The diseases of laryngology require strongly multimedia data for the diagnosis. Data on laryngeal patients can be multiform. They include:

- the doctor's textual memo of the patients,
- the numeric data from the result for the analysis, for example, blood analysis,
- the image data for the radiological examination,
- the sound data from the stethoscope,
- the audio data for the voice sound,
- the motion picture of the walking test,
- the facial expression,
- the video data for the movement of the vocal folds, etc.

Our goal is to develop a collaborative medicine system which permits medical specialists to share the multimedia patient database relevant to laryngeal diseases, and to communicate with each other in real-time on the Internet. We implemented a prototype, named CoMed, which satisfies this goal.

We present here the prototype CoMed, showing its structure in chapter two. We will discuss in detail the design issues of our multimedia database based on the object database O_2 [10,11] and CORBA[12] in the third chapter, and our real-time collaboration system in the fourth chapter. In the fifth chapter, we will describe briefly the ongoing experimentation of CoMed, and finally we will present the conclusion and future work in the last chapter.

2. System Overview

2.1 Overall Architecture

We summarize the global system architecture of CoMed in Figure 1. CoMed consists of following two main sections:

- A multimedia medical database relevant to the laryngeal diseases (This corresponds to the area surrounded by dashes in Figure 1).
- A real-time collaboration system consisting of a video teleconferencing system and a whiteboard and chatting system.

The system is web-based and has client-server architecture. We adopted the O_2 DBMS, CORBA, and CGI (Common Gateway Interface) technologies for the multimedia medical databases. For the teleconferencing system, Active X technology is adopted. For the white board and chatting system, the Java Applet technology is adopted.

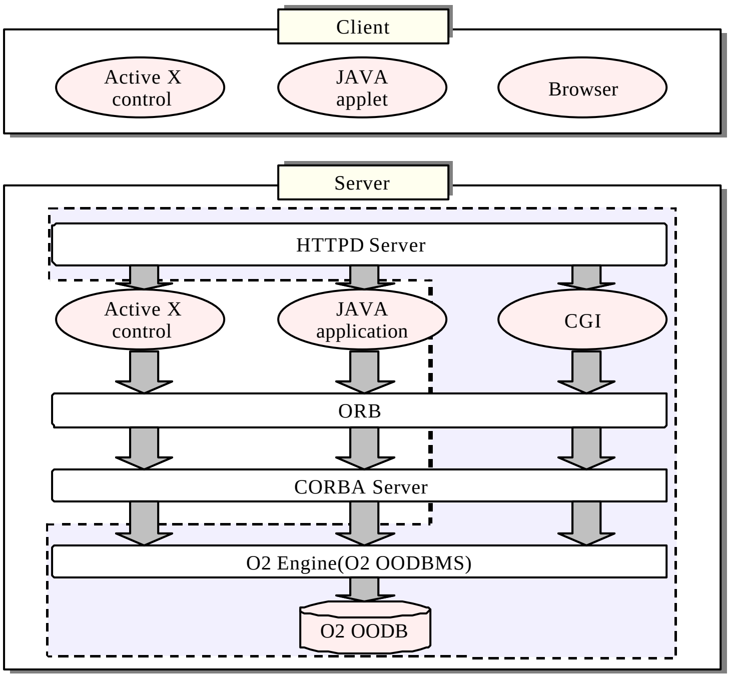

Figure 1. Overall Architecture

The servers of our system is distributed on a Unix machine, which contains the database server, CORBA server and the web server, and a Windows NT machine, which contains another server for teleconferencing. A common Internet accessible personal computer with a video capture board is sufficient to be a client of our system. We will discuss in detail each component of our system in the following two chapters. In the following section, we present the system's functional structure.

2.2 Functional Structure

The major requirements for the proper, real-time collaborative medicine system can be summarized as follows:

- Supporting the accessibility to the multimedia database on the Internet
- Supporting the creation/modification/retrieval of multimedia databases
- Supporting the good quality audio/video captures and real-time transmission for teleconferencing
- Supporting the creation/modification/transmission of the contents on the pen-based white board

Figure 2 shows the functional structure. Every user must register. The user already registered can enter the system directly. After the login, the user can choose the services from functions such as register/search/delete/update for the patient record, use of the white board, chatting facility, the teleconferencing facility, and the bulletin board.

We distinguish six degrees of login level for better security: Admin., Senior Doctor, Junior Doctor, Staff, Patient, and Guest. We limit the right to manipulate the contents of database accessible to the users by these levels. For example, only Senior Doctor and Admin can register the new patient's record.

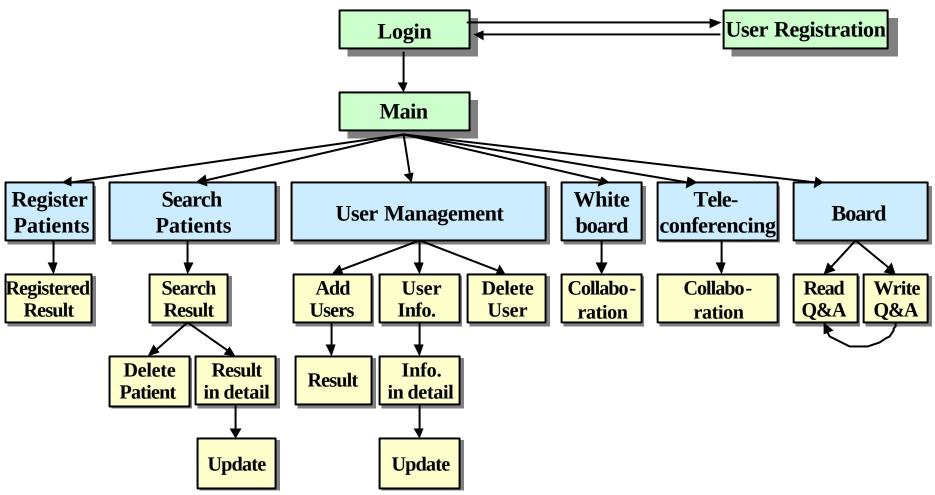

Figure 2. Functional Structure

3. A Multimedia Medical Database

As mentioned before, laryngology involves the five special sensory organs and depends heavily on multimedia data for the diagnosis. Therefore, we need a database management system that permits us to manipulate easily and flexibly, the data. Meanwhile, if we consider the high degree of volume and the complexity of medical data, it is necessary that the medical databases are to be distributed to support the better world-wide collaborative consultation.

The above-mentioned requirements lead us to adopt the O_2 object database and CORBA technologies. The O_2 object database composed of three components. The first component consists of a collection of development tools such as C++, Java, and OQL (Object Query Language). The second component is a database engine that is composed of O_2Search, O_2Spatial, O_2Version, O_2Replication, and O_2Notification. The last component is a collection of external interfaces such as O_2Web (for web), O_2CORBA (for ORB), O_2ODBC (for SQL tools), and O_2DBAccess (for RDBMS)[11]. We can find some existing O_2-based medical database systems [13].

The advantages of O_2 for the construction of our multimedia medical database, are as follows:

- It is possible to design the system in an object-oriented fashion. This simplifies the development procedures and supplies the object-oriented data model that is identical to the Java or C++ data model.
- It is possible to extend the type of data for new applications that need a new type of data, such as multimedia data or complex structure data.

CORBA technology allows us to construct the device-independent distributed application that is more extensible and more flexible than the simple client-server application.

3.1 Class Structure

We designed the database so we do not need to modify the entire structure of the database, even if some components are newly added to the database structure. The O_2 database is composed of objects which start from the 'root'. The 'root' has 'bases', the 'bases' have the 'names', and the 'names' have 'classes'. Figure 3 shows the class structure of our system, consisting of three aspects: doctor, patient, and bulletin board. The classes are designed to make good use of the class hierarchy. For example, “Voice”, “Video”, “Image” classes inherit the properties of the classes “DiseaseID’ and “NeckID” which inherit the properties from the class “PatientID”.

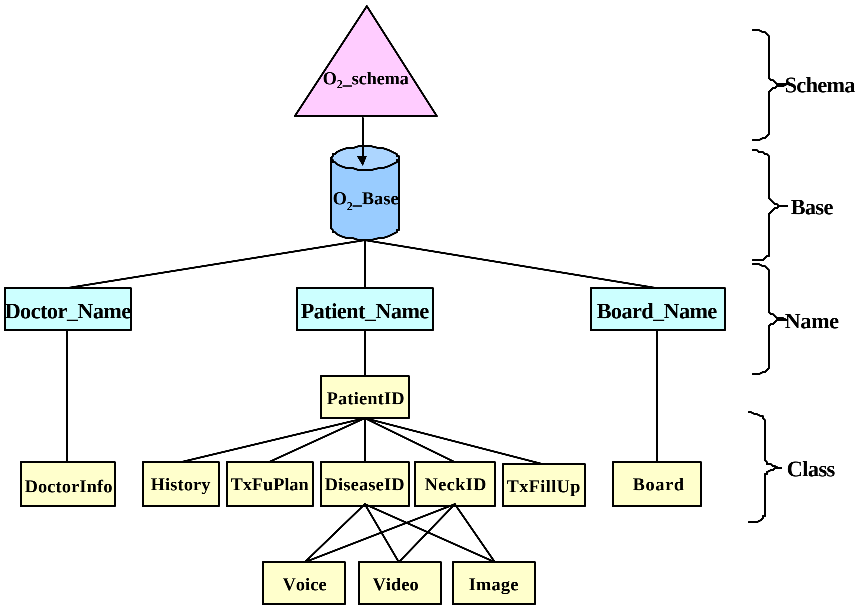

Figure 3. Class Structure

3.2 Patient Data Registry

Here, we present the data registry fields of our database. Currently, we deal with only the patient data concerning the head and neck cancers. The registry fields are classified in five categories, they are Patient ID, Disease Status, Neck Status, TX and F/U, and Tx Summary & Fill-UP Information. Figure 4 shows these categories and their data fields.

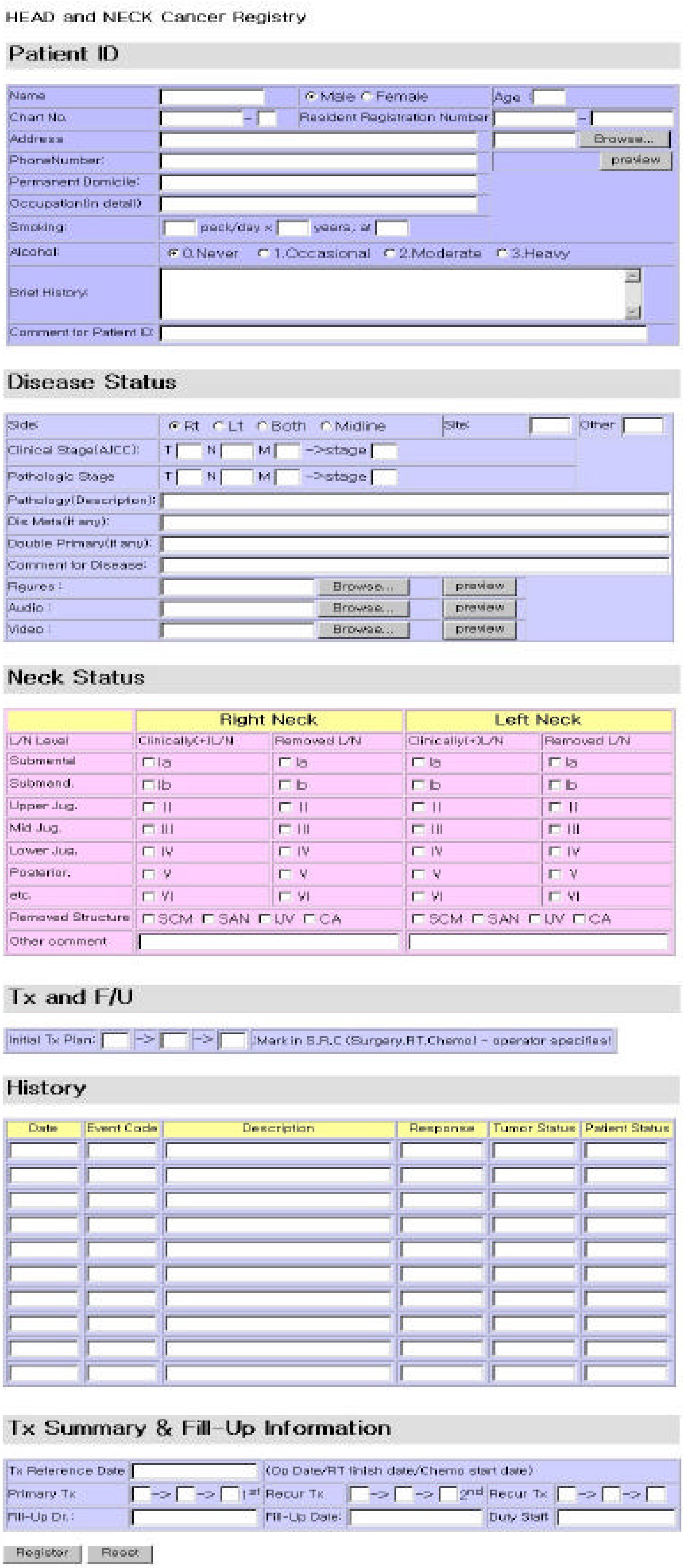

Figure 6. Patient Data Registry

3.3 Search Patient Records

The main reason of using database is to search data. CoMed allows one to search patient records by the patient's name, the chart number, the site (the location of hospital), the fill-up doctor's name, the patient's resident registration number as shown in Figure 5. Any combination of joined search can be possible. For example, the 'Site' field and the 'Fill-up Dr.' field can be specified at the same time. Figure 6 illustrates an example of search results of our system. One of the search results can be selected to refer the full information about the patient. The full information is presented in the form shown in Figure 4.

Figure 5. Search Fields

Search Result

Number	Name	Gender	Age	Chart No.	Telephone	Site	Fill-up Dr.	Select
1	이휘재	Man	33	1234567 - 2	02-456-3476	OCH	김문석	Delete
2	미은정	Woman	33	1384112 - 9	032-456-5678	OCB	김문석	Delete
3	신근재	Man	26	1647876 - 8	032-567-2945	SGM	김문석	Delete
4	정종채	Man	68	4596837 - 6	02-486-2943	OPTB	김문석	Delete
5	전형주	Man	25	5671235 - 3	032-596-3956	OP	김문석	Delete
6	남희석	Man	32	7654321 - 9	02-839-2955	OCR	김문석	Delete

HOME

Figure 6. An Example of Search Results

4. A Real-time Collaboration System

4.1 Structure of the Teleconferencing System

The structure of our web-based teleconferencing system is summarized in Figure 7. The operations of teleconferencing system follows the steps marked by the numbers in Figure 7. If a SeeYou Active X control client requests the connection to the web server (HTTPD server) for CoMed, then the web server transmits the corresponding homepage data. In addition, the SeeYou Active X control client requests the connection to the teleconferencing server (Active X server) in the NT machine. Then the teleconferencing server requests the connection to the CORBA server with the user login information. After the CORBA server accesses to O_2 database and gets information about the registered users and the conferencing group, it passes the information to the teleconferencing server. Then the teleconferencing server transmits user data and the conferencing group information to the client. Each SeeYou Active X control clients transmits the audio and video data from itself to the other members of the conferencing group. When the conferencing session finishes, the SeeYou Active X control client requests the disconnection to the teleconferencing server and the web server.

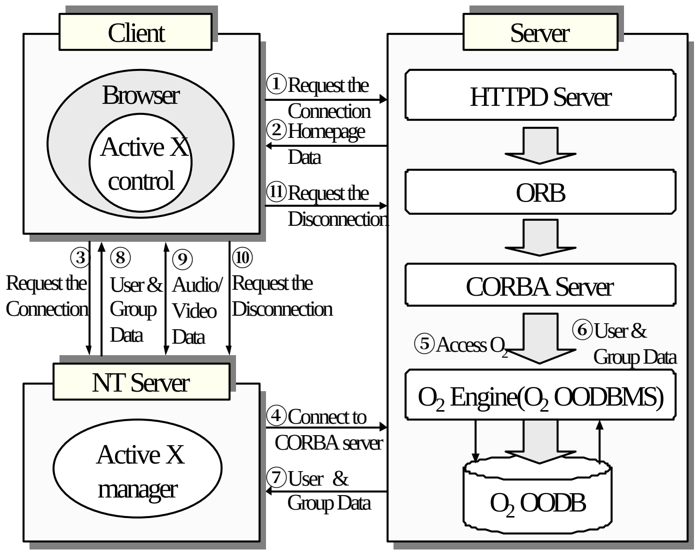

Figure 7. Structure of the Teleconferencing System

4.2 Structure of the Whiteboard and Chatting System

Figure 8 shows the structure of web-based whiteboard and chatting system. We developed a Java application for our whiteboard and chatting system, which is managed by the HTTPD web server. A whiteboard and chatting client (Java applet) requests the connection to the web server for CoMed, then the web server transmits the corresponding homepage data. After the web server accesses to O_2 database and gets information about the registered users and the conferencing group, it transmits the information to the whiteboard and chatting client. Each whiteboard and chatting client transmits the whiteboard and chatting data from itself to the other members of the conference. When the whiteboard and chatting session finishes, the whiteboard and chatting client requests the disconnection to the web server.

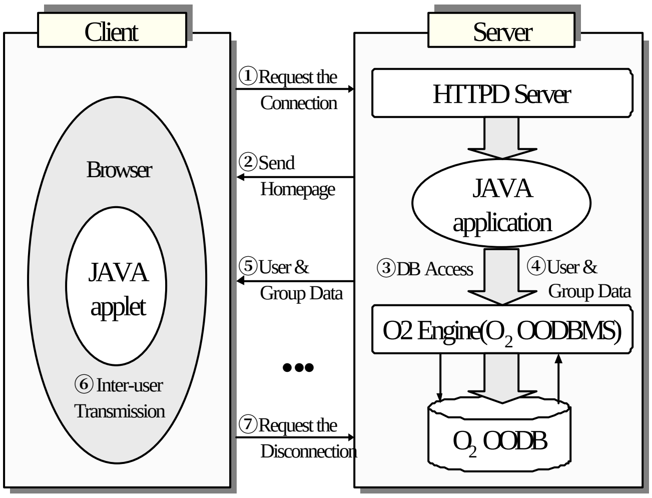

Figure 8. Structure of the Whiteboard and Chatting System

5. Experiments

Our system is now under experimentation with collaboration between Seoul National University Hospital and Cheju Provincial Medical Center. Cheju island is located south of Korea. The experiment will continue about six months or longer to validate the effectiveness of CoMed. The patients are interviewed face-to-face by a laryngology chief resident at the Cheju Provincial Medical Center. The chief resident encounters a case in which he cannot recognize the exact ramification of the disease. The patient requires a more complete examination, not possible at Cheju. Sending the patient to Seoul is possible, but costs are high. The chief resident requests a laryngology specialist in Seoul and a consultation session using CoMed. The laryngeal specialist consults the patient via teleconferencing, and reviews the patient record via patient database in CoMed. The patient stays in Cheju. The specialist requests the chief resident to register the voice recording and video recording of vocal folds of the patient in the patient database of CoMed, so he can examine the waveform and the video data at Seoul.

Figure 9 is a screenshot of our system CoMed, which shows an example of collaborative consultation using teleconferencing and the whiteboard, while examining the search result of a patient.

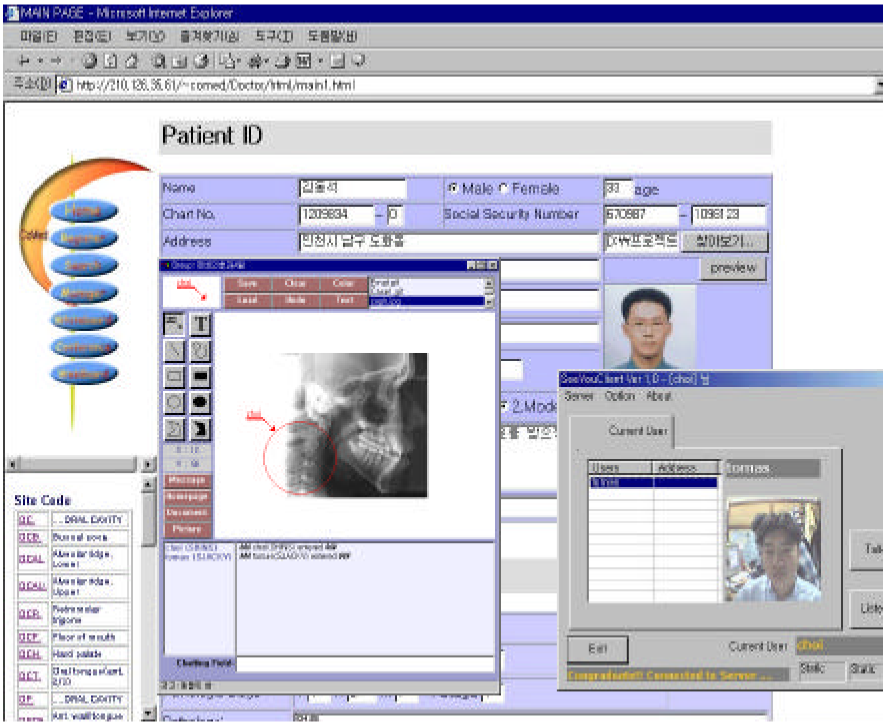

Figure 9. Example of a Collaboration

6. Conclusion and Future Work

In this paper, we presented a prototype telemedicine system, CoMed. We developed a multimedia medical database relevant to laryngeal diseases, a SeeYou Active X control for teleconferencing, and a Java applet for white board and chatting. One of the advantages is that CoMed is available, anywhere, connected to the Internet. The other is extensibility. Our system is based on the object database O_2 and CORBA. This provides the flexibility, extensibility, and location transparency of the patient databases. Moreover, improving efficiency of the overall system by separating the servers on a UNIX machine and a Windows NT machine is also an advantage.

CoMed can be utilized for stand-alone research, for collaborative consultations among medical specialists, and for a telemedicine in participation with the patients and medical specialists. Our system can be extended easily into other types of the collaborative systems, such as collaborative distance learning system, collaborative science system, etc..

In future work, there is possible study of security problems of the multimedia medical database, on the mechanisms of storing and retrieval content of some collaborative sessions, on the optimization of the audio and video data transmission, and on the inclusion of intelligent agents into the system. As well, we need to validate the effectiveness of the system CoMed for collaborative consultations in the field of medicine.

Acknowledgements

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