CHAPTER 8

DESIGN AND DEVELOPMENT OF A TELECONSULTATION FRAMEWORK FOR MEDICAL DIAGNOSIS

8.1 INTRODUCTION

Rapid development of telecommunication networks has made possible the development of telemedicine, and especially one of its segments, medical teleconsultation. Teleconsultation frameworks provide tools for establishing meaningful communication between general practitioners on remote areas and specialists typically located in large medical centres. The advances in technology have led to the development of a wide range of tools for teleconsultation. But, the immediate necessity of the healthcare industry is a tool which would provide a complete framework that could assist any medical practitioner to perform an accurate diagnosis in consultation with experts across the world. The current frameworks available in teleconsultation allow image manipulation and voice communication. However they do not support video consultation. For diagnosis of complex diseases, doctors need dynamic image manipulation with voice communication and video consultation facilities. The existing internet based teleconsultation models fail to provide all these features mentioned above.

8.2 LITERATURE SURVEY

Jianguo et al (2000) have developed a teleconsultation system with high resolution and large volume medical images for use in a clinical
DICOM-PACS (digital imaging and communication in medicine - picture archiving and communication system) environment. Standard DICOM and TCP/IP network protocols have been used. This framework does not support video consultation and voice communication is through telephone. Chronaki et al (2000) have proposed a framework that manages teleconsultation folders (TCF) as shared workspaces. Authorized clients place their request along with patient medical records, which may include images, for diagnosis by an expert. A TCF is created and an expert cardiologist notified. The expert connects to the TCF, reads the records and submits his diagnosis. The client is notified and the consultation is read from the TCF closing the teleconsultation session. This framework lacks real-time consultation with image/video and voice communication facility.

8.3 PROPOSED FRAMEWORK

The framework proposed in this thesis supports both image and video based consultation, with voice communication facility. In addition to this, a direct connectivity to a patient with an image acquisition system enables on-line consultation through Internet Protocol (IP) based communication. The entire framework is designed to work in an open source environment across the internet at a low implementation cost.

The proposed teleconsultation framework is shown in Figure 8.1. The system uses a consultation application which is capable of maintaining the same screenshot in all client terminals. Any medical image or real time video available in a centralized server or with the client or an image captured by an image acquisition system can be uploaded and used for teleconsultation. The participating clients are provided a user friendly interface. The framework also provides a voice based communication facility. Any client can initiate the consultation. The system uses a round robin mechanism for allowing the participants to manipulate the images or play videos. Once a
client makes any change, the change will be reflected in all client terminals immediately. The participants can also simultaneously converse.

![Diagram of teleconsultation framework](image)

**Figure 8.1 Proposed teleconsultation framework**

A teleconsultation framework has to meet the following requirements to support real-time consultation:

- Provide a white board for synchronous image manipulation
- Provide a mechanism for video based consultation
- Maintain a real-time database for controlling different sessions
- Provide or establish high security
- Operate across the internet with acceptable latency
- Be cost-effective right from implementation to maintenance

The proposed framework overcomes the drawbacks of the existing frameworks and meets the requirements of real-time consultation in the following ways:
1. It is designed to work across the internet and no special software need to be installed in the client machines.

2. It uses a whiteboard mechanism to synchronize the screens of the clients in a session. Details manipulated by a client will be reflected at all the participating client terminals.

3. It is equipped with voice communication facility.

4. Video based consultation is included in the framework.

5. It supports on-line consultation with patient using image from an image acquisition system at patient’s premises through IP connectivity.

6. Since working across the internet demands high level of security, Advanced Encryption Standard (AES) algorithm is used.

Image manipulation is the key concept in this framework. Most medical images require only minimal manipulation without loss of information. A typical Magnetic Resonance Imaging (MRI) study consists of about 200 images of 128 Kbytes each; a Computed Tomography (CT) study has about 40 images of 512 Kbytes each. The amount of data for each study is mostly between 20 and 30 Mbytes (Jianguo et al 2000). So an internet based teleconsultation framework must introduce only acceptable latency for such huge data transfer.

Further, internet clients may have different network bandwidths. For example, the initiator of the session can have a high speed broadband connection of 512 Kbps while the other participant may have a relatively slow speed of 128 Kbps. In such cases, poor design may result in heavy latency for synchronizing the screens at the consulting nodes. To overcome this delay the
User Datagram Protocol (UDP) datagram channel is used. Whenever a manipulation is done, only the details of the manipulation are sent to the other participating clients instead of the whole modified image. This technique requires only 16 bytes to report any change to remote clients.

**8.4 IMPLEMENTATION**

**8.4.1 System Architecture**

The centralized server serves as the backbone of the entire framework. Open source products are chosen for the architecture to reduce the cost. The teleconsultation framework comprises of the following modules:

1) Server’s white board
2) Image manipulation
3) Voice capturing and playback
4) Video broadcasting
5) Optimized database for faster data routing
6) Data compression
7) Network security
8) User interface

The server’s white board is developed using UDP. The image manipulation module and voice capturing and playback module are developed using Java. The video broadcasting module is designed using Java’s JMF framework. MySQL, a multi-threaded database management system that provides faster data access amongst the open source products is used in the development of the database module. Data compression is achieved using Java’s Advanced Imaging (JAI). Network security module is implemented
using Advanced Encryption Standard (AES). An easy to use graphical user interface (GUI) is designed using Java.

8.4.2 Image Manipulation

Two kinds of consultation are possible in this framework:

- Consultation based on an image
- Consultation based on a video

Image based real-time consultation requires manipulation of an image of any resolution, size and quality without any loss of information due to manipulation. Loss of information in such an application may lead to wrong diagnosis.

The main objective of the image manipulation module is to maintain the same screen shot on all terminals participating in the consultation. For this purpose, a white board mechanism is implemented using UDP which involves message passing between the clients and the centralized server.

The basic functionality of the GUI at the client side is to provide a set of tools for image manipulation as depicted in Figure 8.2. The common functions of image manipulation provided are transforming the image across the scales, rotating the image, tilting the image by fixed degrees, zooming in or out the image, changing the brightness and contrast of the image, sharpening the image, blurring the image, detecting edges of the image and increasing any single colour band (RGB) of the image.
Apart from these basic functions, clients are provided additional facilities to highlight portions of an image for discussion with their peers. Highlighting can be done by drawing the basic shapes like circles, rectangles, squares, lines or any shape using the pencil tool as indicated in Figure 8.2.

When a client manipulates the image using the above functions, the details about the change alone is submitted to the server. The server broadcasts this information to all the clients. Thus a synchronized screen shot is maintained at all the nodes. Since the bulk image is not transmitted after every manipulation, the framework operates at the same speed irrespective of the network bandwidth.
In general, the teleconsultation is between general physicians or practitioners at remote villages and experts at corporate hospitals. The display used by them may have varying characteristics. To keep the results of image manipulation, such as mouse moving positions, consistent on both local and remote systems the communication module uses only image-relative coordinates for message exchange instead of screen-relative coordinates. This allows systems with different screen resolutions to be used.

8.4.3 Video Consultation

Java Media Framework (JMF) is used for developing a video player in this framework. This Media Framework developed by Sun Microsystems Inc., supports both playing and broadcasting a video. This built-in feature of JMF reduces implementation cost. As shown in Figure 8.3, the video player interface allows the clients to play, pause and resume a video.

Figure 8.3 Screenshot of video player interface
8.4.4 Voice Communication

Java’s line based voice capturing mechanism is used for voice communication in this framework. The server maintains a separate table for updating the status of the ongoing sessions. The location of each client participating along with the session in which the client is participating is stored as the session information by the server. This table is dynamically updated based on the control information provided by the clients.

Every time a client speaks, the audio is captured at the client terminal and transmitted to the server. On receiving the voice data from any client, the session to which this originating client belongs and the other participating clients of this session are identified by the server. Once this is known, the server broadcasts the voice data to all participating clients except the source. At the receiving ends the voice data is played back in the captured audio line format.

8.4.5 On-line Consultation

Another salient feature of the proposed system is the provision of a direct connectivity with a patient. A patient at home can be connected to the server with an image acquisition system as shown in Figure 8.4, through an IP protocol. This is a low-cost embedded system with a camera that captures and sends images to the server in the teleconsultation framework. On receipt, the server routes the image to a logged-in expert or in their absence stores the image and sends an alert message. When an expert logs in, the image is directed to the expert for consultation.
8.5 TELECONSULTATION PROCEDURE

The teleconsultation protocol follows the sequence given below.

**Authentication:** The first step is to authenticate the initiator of the session. This client is called the super client or owner of the session. The owner can invite peer clients to participate in this session by sending a request to them. The transaction table is updated by the server based on the clients’ acceptance.

**Dynamic framework configuration:** In this step, the owner chooses the kind of consultation needed. If the consultation is based on an image, the white board is loaded with image manipulating functions. If consultation is based on video, then the video player is loaded. For either case, the voice communication facility is available.

The images and videos stored in the server are in a compressed and encrypted form. Joint Photographic Experts Group (JPEG 2000) and Moving Pictures Experts Group (MPEG) standards are used for image and video compression respectively. AES is used for encryption.

When a client uploads a new image or video, it is compressed and encrypted in the same formats as above and the encrypted file is then transmitted to the server. The server stores this encrypted file along with its encryption specification key details.
When the session starts, this encrypted file is automatically downloaded at the participating client terminals using the session details provided by the owner along with its encryption specification keys. At the client end, the file is decrypted, decompressed and displayed.

**Framework presentation:** This step synchronizes all clients in the session. In image based consultation, all clients are presented with the same screen shot. For video based consultation, the video is played at the same rate at all terminals.

In order to achieve synchronization between the terminals, a token passing mechanism is provided in this framework. Initially, the owner of the session holds the token. It is then released to any client upon request. On receipt, the client can use this token to manipulate images and videos. Any action done by a client is submitted to the server and the server then reflects this change on all clients’ terminals. The entire modified image is not transmitted but only the code containing the action to be performed and its data, like the coordinates are transmitted. On receiving this message, the client machines extract the details of the action and implement the change locally.

**Figure 8.5 Control flow in proposed framework**

Figure 8.5 summarizes the control flow in the proposed framework. The owner initiates a session and configures it. He then invites other
authenticated clients to join the session. Any change made by the owner is submitted to the server through the whiteboard. The server uses the transaction table to reflect the changes through the individual whiteboards of the clients. A participating client can also make a change by requesting for the token and on receipt can make changes and submit to the server. The server then reflects the changes to all the participants.

8.6 SUMMARY

In this chapter, the design and development of an internet based teleconsultation framework was discussed. The framework provides a platform for consultation based on image and video. The use of open source products ensures a cost effective, highly efficient and secured teleconsultation framework. This framework can effectively connect doctors across the globe and assist in delivering high level of healthcare services. Further, providing direct connectivity to patients help experts acquire images for offline consultation between experts and on-line consultation with patients. It is perceived that in future such gadgets would be made available at home to monitor and transmit physiological signals and images to hospitals through internet promoting patient centric healthcare services.