A TELECONSULTATION FRAMEWORK FOR MEDICAL DIAGNOSIS

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Abstract

Rapid development of telecommunication networks has made possible, the development of telemedicine, and especially one of its segments, medical teleconsultation. In this paper we present a system which is designed to provide tools for establishing meaningful communication between general practitioners on dislocated areas and specialists typically located in large medical centers. The proposed system based on emerging technologies represents a base for providing a higher level of health care.

The system uses a consultation application which is capable of maintaining the same screenshot in all client terminals. The medical images / real time videos stored in a centralized server or uploaded by a client is 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, then the change will be reflected in all client terminals immediately. The participants can also simultaneously converse.

The current frameworks available in telemedicine allow image manipulation and voice communication. However they do not support video consultation. The proposed system is a low cost framework which supports both image and video based consultation, with voice communication facility.

The framework is developed using MySQL and Java. MySQL an efficient open source DBMS is used for storing user information and medical data. Java is used to develop user interface for the framework.

This proposed system would enable doctors to be in touch with their peers and assist them in providing quality and timely health care to the society.

Index Terms : health care, image manipulation, telemedicine, video consultation

I. Introduction

The advances in technology have led to the development of a wide range of tools for telemedicine. But, the immediate necessity of the health industry is a tool which would provide a complete framework that could assist any medical practitioner to perform an accurate diagnosis by consultation with experts across the world.

The existing internet based models provide the following facilities:

1. Projection and Manipulation of still images
2. Voice based communication.
3. Video conferencing facility.

For diagnosis of complex diseases, doctors need dynamic image manipulation with voice communication and video consultation facilities. The existing internet based models fail to provide all the three features in one.

In this paper, a specialized teleconsultation framework is presented which supports and works similar to the existing teleconsultation models and, in addition provides video-based consultation. The entire framework is designed to work in an open source environment across the internet at a cheaper implementation and maintenance cost.

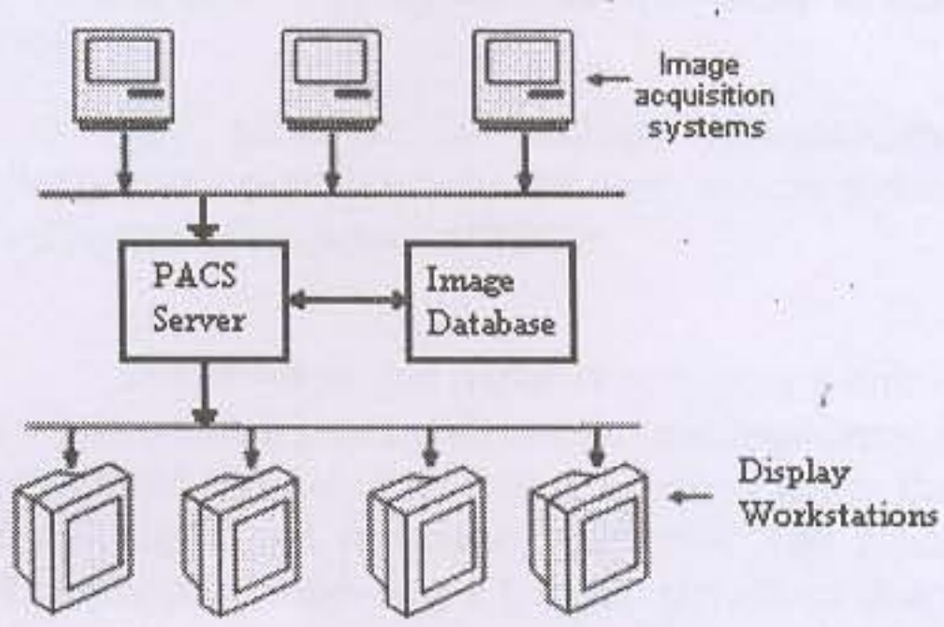

Fig. 1. PACS Model

II. Existing Model

Fig. 1 shows the PACS (Picture Archiving and Communication System) model used by hospitals widely nowadays. Image acquisition systems acquire the images and they are stored in the centralized PACS server in DICOM format. Any number of local clients can view this image immediately and manipulate it. This model works perfectly only within a Virtual Private Network or a Local Area Network. This places a constraint on the clients that they can access the patient's information

only within a LAN environment [1]. Fig. 2 shows an existing internet model integrated to a PACS environment[1]. This model has various drawbacks. First, the clients viewing the same image do not have any voice communication facility other than the traditional telephone connection. Second, historic videos have no place in this model. DICOM standard uses image sets. These images are sequentially changed at constant speed providing an illusion of a video. The PACS model supports only static images and there is no provision for standard video format like MPEG. This restricts the integrated teleconsultation framework from video consultation. Finally, PACS does not give much importance to the security of the data since it is based on a secure hospital network environment. On the contrary, an internet based model needs stringent security measures to prevent unauthorized access. The proposed model is designed to overcome all these drawbacks.

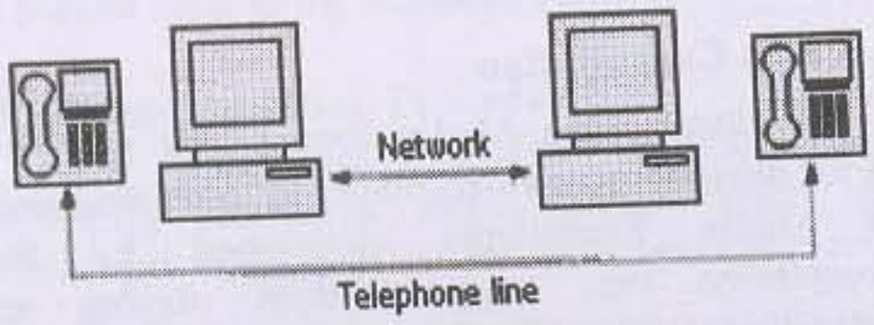

Fig. 2. Existing Model

III. Requirements

The framework is developed to meet the following requirements for real-time consultation:

- Provide a white board for synchronous image manipulation.
- Provide a mechanism for video based consultation.
- Be cost-effective right from implementation to maintenance.
- Real-time database for controlling different sessions
- Be highly secure across the internet.
- Operate across the internet with acceptable latency.

IV. Proposed Model

The proposed model overcomes the drawbacks of the existing models and meets the requirements of real-time consultation in the following ways:

1. Since the proposed framework is designed to work across the internet, no special software has to be installed in the client machines.
2. The proposed model 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. Framework is equipped with voice communication facility.
4. Video based consultation is also part of the framework using which the doctors can consult based on a video.
5. Working across the internet demands high level of security. So, the framework is made more secure by AES (Advanced Encryption Standard) encryption algorithm for data security.

In this framework, image manipulation is the key concept. Most medical images require only minimal manipulation without loss of information. A typical MR study consists of about 200 images of 128 Kbytes each; a CT study has about 40 images of 512 Kbytes each. The amount of data for each study is mostly between 20 and 30 Mbytes. 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 UDP (User Datagram Protocol) datagram channel is used. Whenever a manipulation is done, only the details of the manipulation are sent to the other participating clients instead of sending the whole modified image. This technique requires only 16 bytes to report any change to remote clients.

V. Teleconsultaion System Design and 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 the following modules:

1) Server's white board
2) Image manipulation
3) Voice capturing and playback
4) Video broadcasting

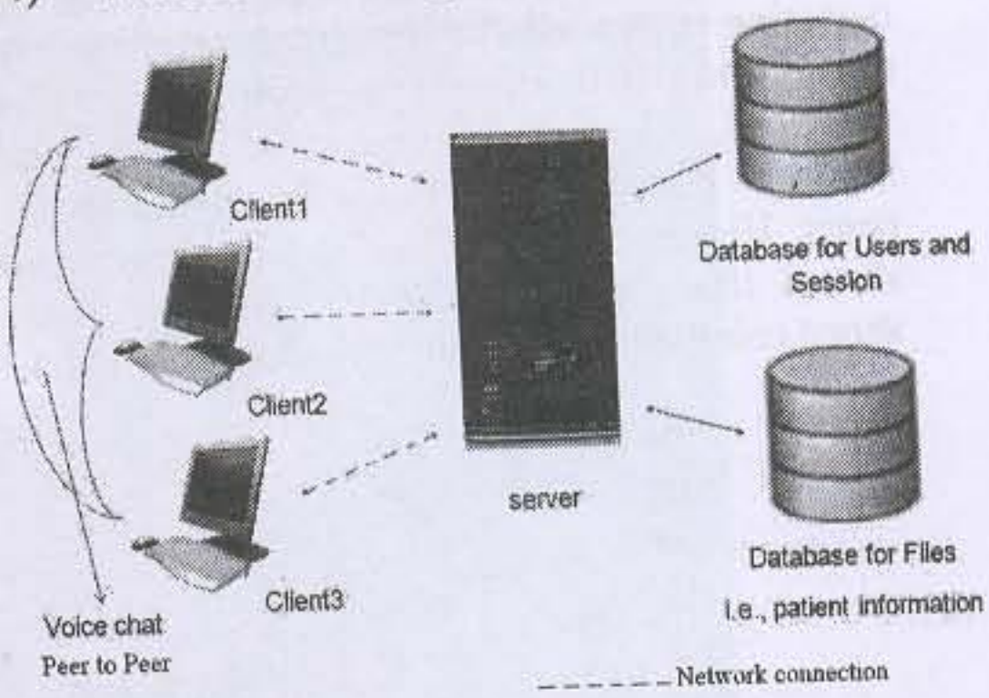

Fig. 3. Proposed Model

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 [4]. The video broadcasting module is designed using Java's JMF framework [2]. 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 GUI (graphical user interface) is designed using Java [3].

VI. 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 Fig. 4. 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 of the image, changing the brightness and contrast of the image, sharpening the image, blurring the image, detecting edges of the image, increasing any single color 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 Fig.4.

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 and experts. The display used by them will 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.

VII. Video Consultation

Java's 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 [2]. This built-in feature of JMF reduces implementation cost. As shown in Fig. 5, the video player interface allows the clients to play, pause and resume a video.

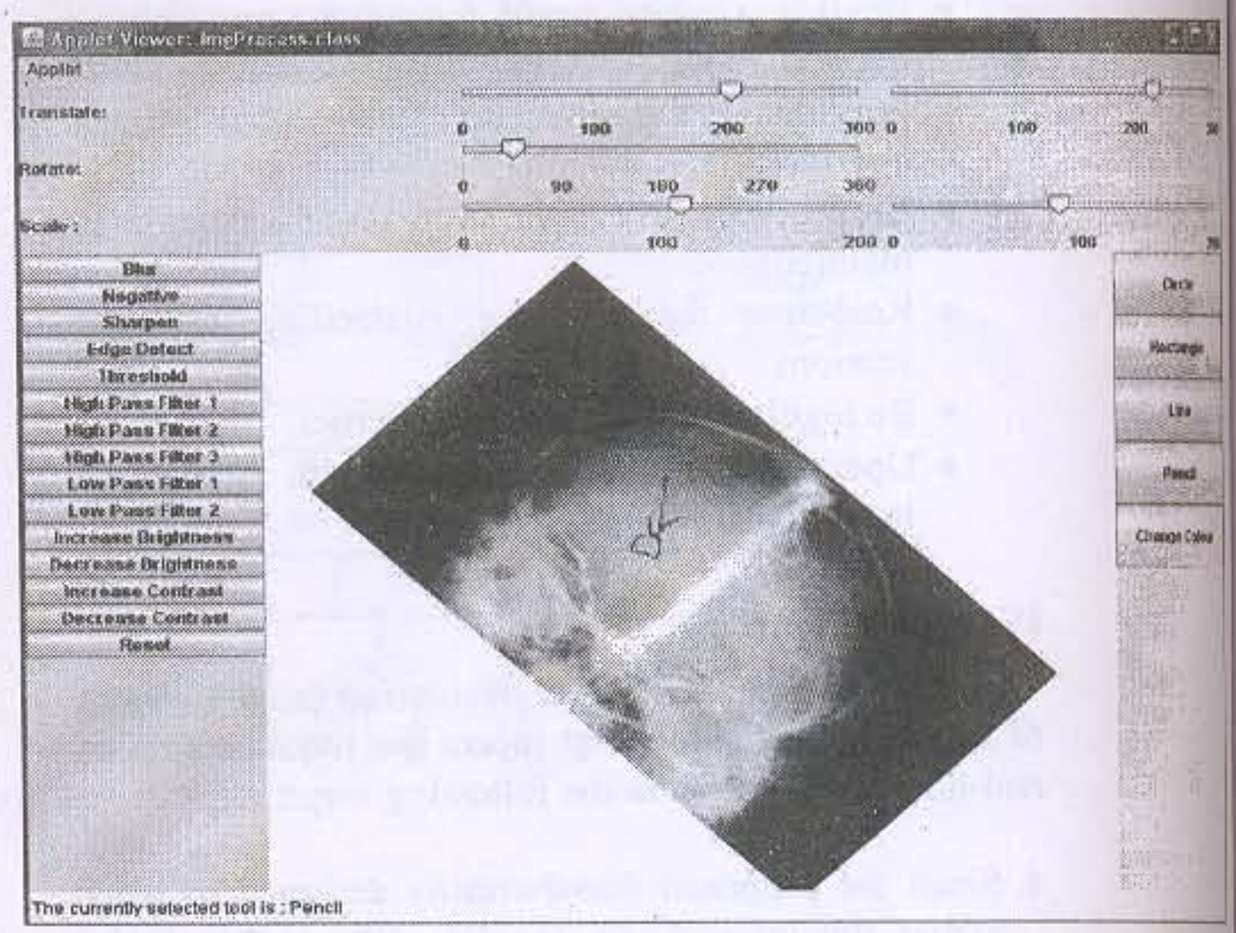

Fig. 4. Image Processing Screenshot

VIII. 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.

IX. Teleconsultation Procedure

The teleconsultation protocol has the following sequential steps: authentication, dynamic framework configuration and framework presentation.

Authentication: The first step is to authenticate the initiator of the session. This client is called the super client or owner of the session. 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 compressed and encrypted form. JPEG 2000 and MPEG (Moving Pictures Experts Group) 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, 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 is started, 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 designed for the framework. Initially, the owner of the session holds the token. It is then released to any client upon request. On receipt, the client can then 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.

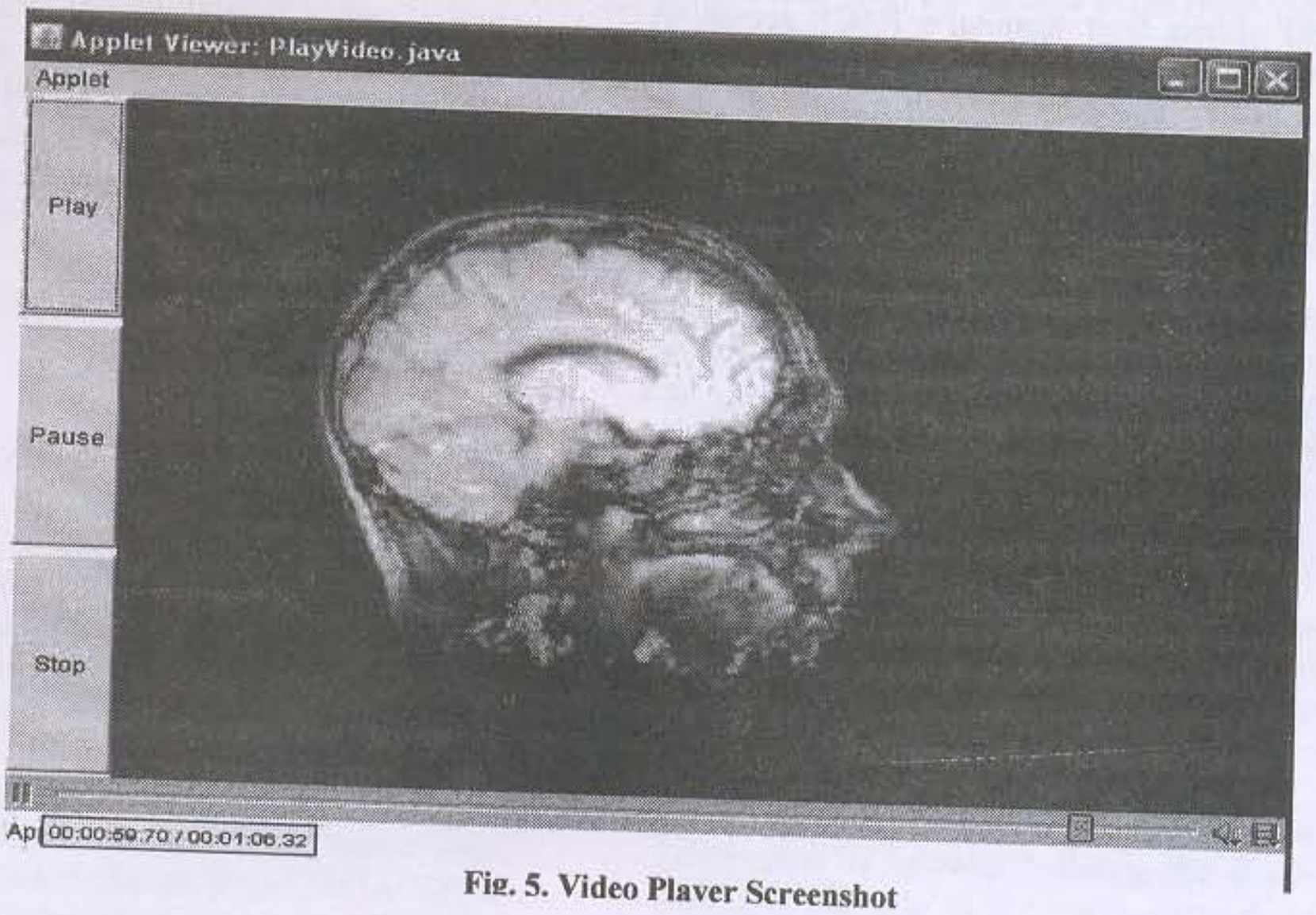

Fig. 5. Video Plaver Screenshot

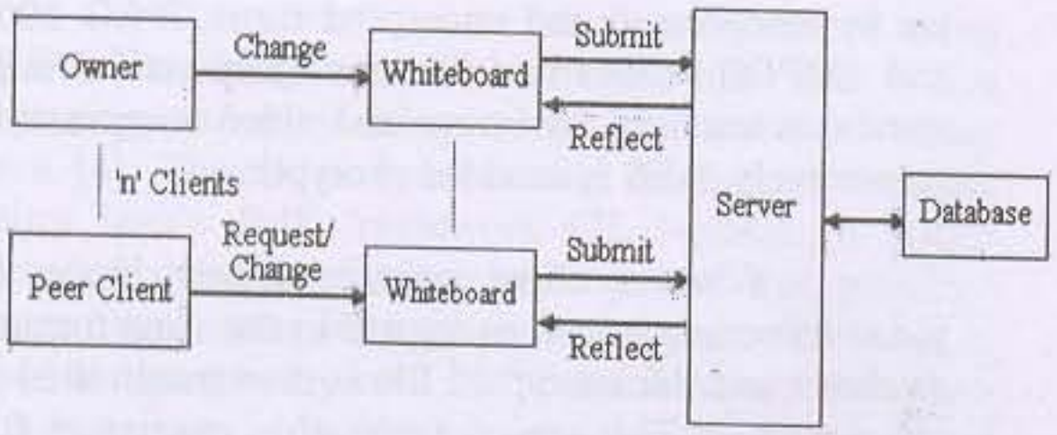

Fig. 6. Control Flow in proposed model

Fig. 6 summarizes the control flow in the proposed model. 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.

X. Conclusion

An internet based teleconsultation framework has been developed. The framework provides a platform for consultation based on image or 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 providing high level of healthcare services.

XI. Suggestions for Future Work

PACS is widely used in hospitals. This framework can be extended allowing the clients to connect and access their hospital's PACS server. A desktop application can be developed which can intimate an offline client by sending a notification to the client's personal computer or mobile phone. Based on the urgency of the request, the framework may select the appropriate device [5].

Most of the internet based collaboration techniques support video conferencing. JMF provides Real Time sessions for video conferencing. This framework can be extended for video conferencing using this feature.

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