An Adaptive Multimedia Transmission Control for Telemedicine Applications

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Abstract- *In the telemedicine applications, multimedia information may contain various media objects, such as video, audio, medical image, image annotation, and consultation control messages. Different object types have different proprieties such as presentation importance, quality requirement, priority, and the tolerance of the transmission delay and loss. Due to the network heterogeneity, resource constraints, and random traffic characteristic, the transmission of the media objects may encounter the packet delay, loss, and jitter. For the proper presentation of multimedia objects during the tele-consultation, the multimedia transmission necessitates an intelligent mechanism. In this paper, an adaptive multimedia transmission control mechanism for telemedicine applications is proposed to reduce the network affection. According to the characteristics of telemedicine applications, different types of media objects are classified and applied to different transmission approaches to enhance the efficiency of bandwidth and quality of service. The bandwidth is dynamically allocated depending on the characteristics of the transmitted data so that the utilization of bandwidth is promoted, and quality of service is maintained.*

Keywords: Multimedia, Telemedicine, CSCW, Stream.

1. Introduction

The evolution of multimedia technologies and broadband networks bring packet-based convergence to the communication environment, allowing voice, video, and data to come together through a single unified channel [1], [2]. The communication network makes dramatically more efficient, convenient, and cost-effective in many aspects. Therefore, many multimedia applications are emerged, such as telemedicine, tele-education, tele-shopping, video on demand, video conference, and other convenient multimedia information services. All these applications can be treated as some specialized cases of a distributed multimedia information system. The multimedia information system may contain various media objects, such as video, audio, and text. To overcome the network affection including the transmission delay, loss, and jitter, different object types need different transmission policies according to their application.

In nature, telemedicine system is also one kind of the multimedia systems which provides remote access to patient data and makes medical consultation available to distant communications [3]-[6]. However, the characteristics of the telemedicine applications differ from the other multimedia information systems such as video on demand, or conventional video conference system. Some types of media objects are important, and need to be delivered in real-time, such as control messages. The others types of media objects are tolerant for delay or loss in transmission, such as video and audio.

In this paper, we propose an adaptive multimedia transmission mechanism for telemedicine applications to enhance the efficiency of bandwidth and reduce the network influence. The mechanism gives different transmission policies for different kinds of the media objects, such as transmission priorities, protocol, and bandwidth.

This paper is organized as follows: Section 2 describes the characteristics of multimedia data for telemedicine application. In Section 3, we present multimedia transmission control mechanism. In Section 4, we give a performance of our proposed method over an experimental telemedicine transmission testbed. Section 5 concludes the paper.

2. Characteristics of Multimedia Data for Telemedicine Applications

A telemedicine system is used to deliver the healthcare services to the remote site through the network communication regarding the geographical distance. Thus, the physicians can discuss and diagnose the disease cases together via the system. The communication data in the telemedicine system should include video, voice, medical image, image annotation, telepointer messages, and some control messages to achieve the interactive discussion. A practical telemedicine system has to fully support the

Computer-Supported Cooperative Work (CSCW) [7]-[8]. In our implementation, the CSCW module includes video and audio conferencing, shared workspace, and some drawing tool for the images discussions.

Video and audio can tolerate some information loss without affecting the play-out quality perceivable by the users, so that the occasional data skipping or discarding does not dramatically degrade the presentation quality. The MPEG-4 video codec is adopted in the system. There are three types of coded video pictures including I-frame, P-frame, and B-frame. I-frame is independently coded and provides reference for P and B frames. P-frame is predictive-coded which requires reference to a past I-frame for decoding. B-frame is a bidirectionally-predictive picture which requires reference of past and future I-frame or P-frame for its decoding. Therefore, I-frame is more important than the other frames in transmission. I-frame is assigned a higher transmission priority than P-frame and B-frame.

Shared workspace provides a remote discussion environment. For keeping the environment consistent, “what you see is what I see” (WYSIWIS) views should be achieved. There are two types of WYSIWS model: strict WYSIWIS and relaxed WYSIWIS [9]. The strict WYSIWIS model, where participants see exactly the same screen, has existed limitations such as display device, display resolution, human usage, etc. For this reason, in our implementation, relaxed WYSIWIS model, which maintains the same window of document rather than keep exactly the same display, was adopted. Users can arrange their windows layout for suiting their display, such as toggling tool bars, moving/resizing windows, and adjusting their resolution. Therefore, the relaxed WYSIWIS model is more flexible and suitable for the human factors.

For maintaining the same document windows of relaxed WYSIWIS model and supporting telepointer, many kinds of messages should be transmitted and exchanged during consultation. Cursor moving messages are used to present the movements of remote cursors; window control messages are used to maintain the consistency of document windows after resizing, zooming, leveling, and other GUI commands. Drawing tools and annotation text messages are used for ROIs telemarking and text comments embedding. Conference commands messages are used to provide the conferencing control such as user login/logout, join/leave, invite/kick, etc. In addition, image processing commands messages are used to trigger the image processing commands on the remote sites.

In order to transmit these messages appropriately and efficiently, four transmission formats, system-defined, Microsoft Windows Message, file transfer, and drawing tools formats, as shown in Fig. 1, are defined to carry the messages mentioned above. System-defined format is used to transmit the system communication commands such as conferencing commands. Microsoft Windows Message format is designed to carry Microsoft Windows Messages, e.g., cursor movement, button click, and menu items of image processing, etc. File transfer and drawing tools formats are used to transmit the files and deliver object-drawing commands, respectively. Based on the definition of formats, maintaining the consistency of the views between different participants is achieved by the transmission of the short-code commands, rather than the image of the entire application window. The bandwidth required is thus significantly reduced due to decreasing the network traffic during consultation.

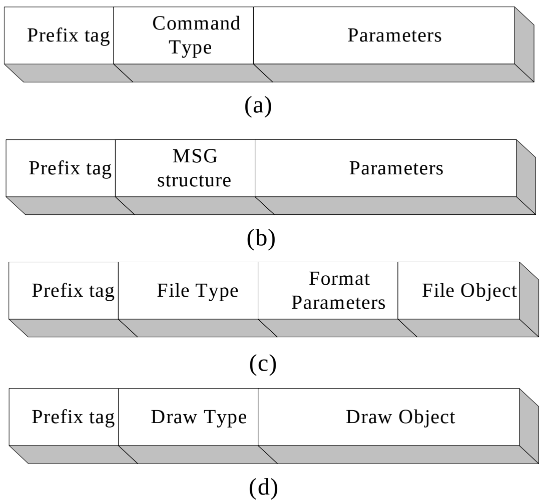


Figure 1. Data transmission format. (a) System-defined format. (b) Microsoft Windows message format. (c) File transfer format. (d) Drawing tools format.

To farther speedup the network transmission and lower the transmission latency, protocols UDP and TCP are applied in the transmission of different messages according their tolerance capability to packet lost. As cursor moving messages are used to indicate the cursor position of other users, occasional packet loss does not cause vital effect for the system. Therefore, a connectionless protocol, UDP, is used to transmit the cursor moving messages for improving the transmission efficiency, increasing real-time interactivity, and reducing the bandwidth required. On the contrary, packet loss of other messages would cause system fatal error. Therefore, the transmission of these messages must be reliable, and TCP transmission was adopted. In order to further enhance the efficiency of bandwidth and quality of service, different kinds of the application data such as voice, images, command message, shape annotation, cursor message, and video are assigned a different priority from higher to lower, respectively. The bandwidth is then dynamically allocated depending on the priority of the transmitted data. For instance, when a user wants to retrieve images (the video stream), which has the lowest priority, will be paused to release the bandwidth for accelerating the transmission. By this approach, the utilization of bandwidth is promoted, and quality of service is maintained.

3. Multimedia Transmission Control

During the consultation proceeds, many types of data are needed to transmit for maintaining the consistency of the shared workspace and providing the functionality of communication. In order to utilize the bandwidth and effectively enhance the system performance, a streaming management module is built in the system to manage the data transmission including shared workspace data (window control, drawing tools, conference command, medical image, image processing and telepointer) and video conferencing data (video and voice). The design of the module contains three mechanisms: A) message classification, B) message prioritization, and C) message queues. Incorporating with these mechanisms, the data will be appropriately transmitted according to its properties.

3.1. Message Classification

To speedup the network transmission and lower the transmission latency, UDP and TCP protocols are applied in the transmission of different messages according their tolerance capability to packet lost. The UDP messages include video, voice, and telepointer messages while the TCP messages include window control, drawing tools, conference command, medical image, image processing messages.

3.2. Message Prioritization

The types of data stream are classified into three kinds with different priorities (high, medium, and low). The high-priority data includes window control, conference command, and image processing command. The medium-priority data includes voice, drawing tools messages, patient data, and telepointer. The low-priority data includes medical images and video stream.

3.3. Message Queues

The message queues are used to realize the message prioritization. Four message queues are implemented in the system as shown in Fig. 2, such as outgoing queue, high-priority pending queue, medium-priority pending queue, and low-priority pending queue. The outgoing queue contains the messages which are ready for sending out. The high-priority pending queue contains the messages possessing the high priority. The medium-priority pending queue contains the messages possessing the medium priority, and the low-priority pending queue contains the messages possessing the low priority.

When the outgoing queue is not full, the streaming management module selects the next message to be sent as follows:

(i) Send the oldest message in the high-priority pending queue.

(ii) If there are no messages in the high-priority pending queue, send the oldest message in the medium-priority pending queue.

(iii) If there are no messages in the medium-priority pending queue, send the oldest message in the low-priority pending queue.

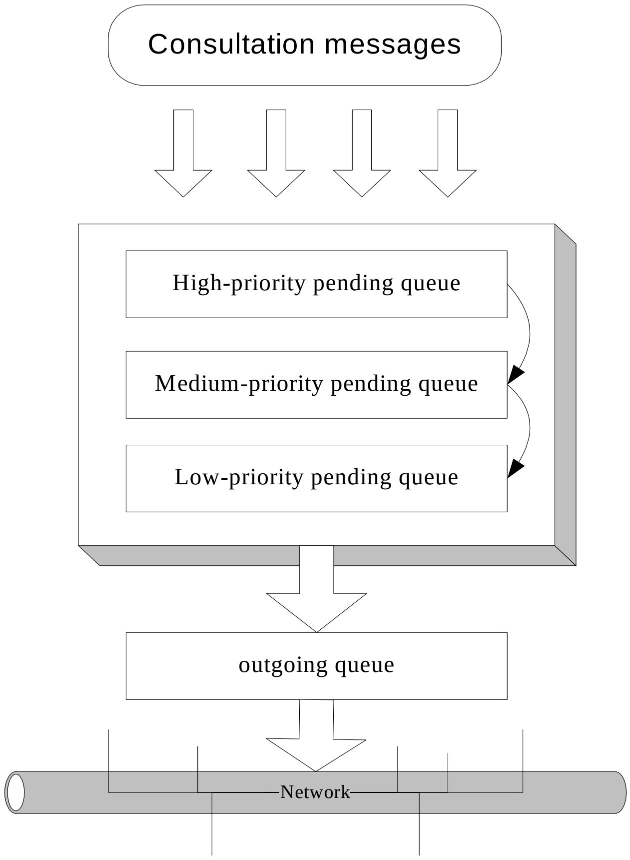
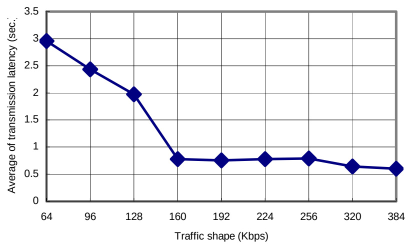


Figure 2. Message queues of streaming management.

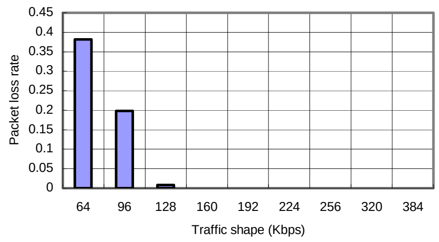
These above mechanisms enable the time-critical messages out as quickly as possible, even when less important messages have already been submitted. However, messages might spend a relatively long time in a pending-message queue, especially if they are low priority. Some messages might stay long enough to have been superseded by subsequent messages. These messages are no longer relevant. For example, the cursor movement messages and video frame messages. To overcome this problem, a timeout value is adding into the message format. If the message is still in a pending-message queue when the timeout expires, the message will be canceled. By this approach, the utilization of bandwidth is promoted, and quality of service is maintained.

4. Experimental Results

To evaluate the multimedia transmission mechanism, we measured the transmission latency and the packet loss rate of the cursor movement messages of the telepointer over different traffic shapes since telepointer provides a major communication tool when the consultation proceeds. According to Fig. 3, it can be seen that the average transmission latency quickly decreases from 2.956 sec to 0.778 sec while the available traffic shape increases from 64 Kbps to 160 Kbps, and the packet loss rate is reduced to 0. Therefore, we can know that the minimum bandwidth requirement of our CSCW module is about 160 Kbps.



(a)



(b)

Figure 3. Performance of the telepoint movement over different traffic shape. (a) Average of the transmission latency. (b) Packet loss rate during the messages transmission.

5. Conclusions

Merging medical imaging with multimedia data becomes a trend of telemedicine systems. The transmission of large-volume medical images and supporting of the real-time and high-quality video conferencing are essential for the telemedicine. In this paper, we propose a multimedia transmission mechanism for telemedicine applications. Based on the stream management, the bandwidth can be utilized efficiently according to the properties of the data and the network traffic is also reduced.

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