Telemedicine with Digital Video Transport System over the Korea-Japan Cable Network

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Abstract

Aim: Transmission of high quality moving-image is essential for telemedicine, which needs standardization of medical techniques and healthcare beyond geographical borders. The aim of this study is to establish a broad-banded medical network between hospitals in Korea and Japan using Digital Video Transport System (DVTS) over Internet protocol.
Method: We used Asia Pacific Internet Infrastructure(APII) and Kyushu GigaPOP (QGPOP) (Japanese side), the Korea Advanced Research Network (Korean side), and the Korea-Japan Cable Network (international line). We performed Korea-Japan medical teleconferences with bi-directional transmission by DVTS streaming on IPv4 network.
Results: The teleconference and surgical video transmission with DVTS over Internet protocol was successfully performed. We could keep enough bandwidth of 30 Mbps for a line of transmission. The quality of the transmitted moving image had no frame loss with the rate of 30 per second. The sound was also clear and the time delay was less than 0.01 sec.
Conclusion: We have established an international medical network with high-quality video transmission over Internet protocol, which is easy to perform, reliable, and also economical. This will be a promising tool in remote medicine for the two countries and for worldwide telemedical communication in the future.

Keywords:

Telemedicine; Digital Video Transport System; Internet protocol; Korea-Japan Cable Network

Fig1. Map of the Korea-Japan Cable Network

Introduction

As the Internet widely spreads in the Asian region including Korea and Japan, the significant progress of broadband services has lead to rapid growth of the demand for telecommunications. Although low-grade moving images are frequently transmitted and are useful in daily life, they

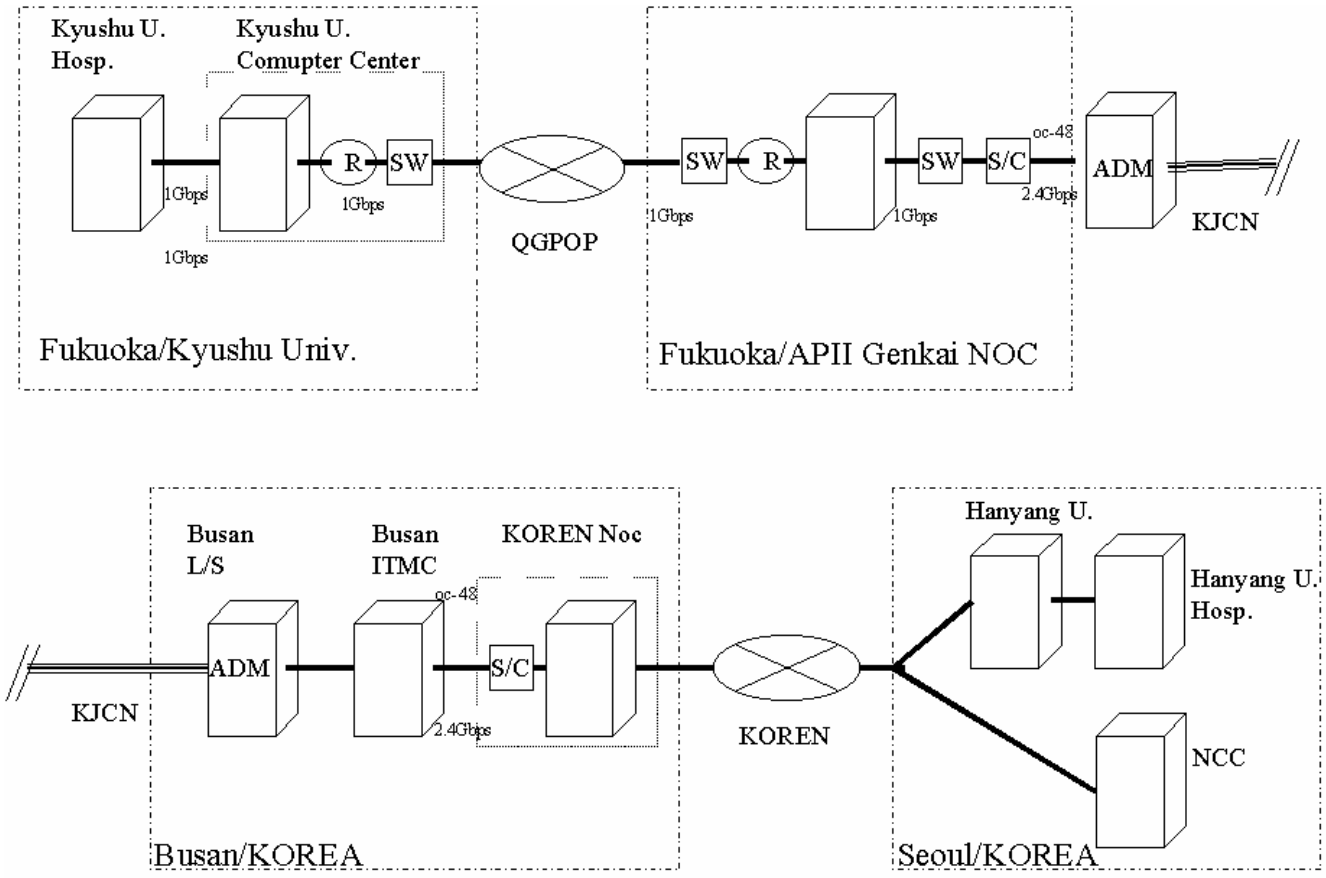

Fig2. Network configuration

are not satisfactory in quality for medical purposes. High-quality images, minimal delay in transmission and multiple channels for voice or various contents are prerequisite elements to make an accurate diagnosis or to recognize anatomy in detail.

The ultra-high bandwidth optical cable system between Korea and Japan, named as the Korea-Japan Cable Network (KJCN), was built in 2001 (Fig.1) [1]. Before its construction, no network was available between the two countries for high-quality moving images. Now a high-standard telecommunication is expected to be developed.

Here we report a newly established international network system for remote medicine with Digital Video Transport System (DVTS) on KJCN.

Materials and Methods

The Hyunhae/Genkai project was established to use the KJCN for development of informatics research and friendship between Korea and Japan. As a subproject of the Hyunhae/Genkai project in medical field, we started to use KJCN for medical teleconference and remote medicine.

We connected the first network between Hanyang University and Kyushu University Hospital on February 12th, 2003, and the second network between Korean National Cancer Center (NCC) and Kyushu University Hospital and on July 25th, 2003.

Network configuration (Fig. 2)

As shown in Fig. 2, we used several networks to connect Fukuoka and Seoul area.

The distance between Kyushu University Hospital and APII Genkai Network Operation Center (NOC) is about 10 km. We used QGPOP between APII Genkai NOC and Kyushu University. The KJCN cables lay submarine between Busan and Fukuoka. The distance between Busan Landing Station and Fukuoka APII Genkai NOC is about 300 km. The length of Korea Advanced Research Network (KOREN) between Busan and Seoul area (Hanyang University Hospital or NCC) is 300 km [2].

Terminal systems organization (Fig. 3)

So far, we made two Korean terminals (Hanyang University Hospital and NCC) and one Japanese terminal (Kyushu University Hospital). We set up teleconference system and streaming system of recorded video image with bi-direct transmission using DVTS over IPv4 on the network described above. We used DV Stream (Fujitsu Co., Tokyo, Japan) to set up DVTS.

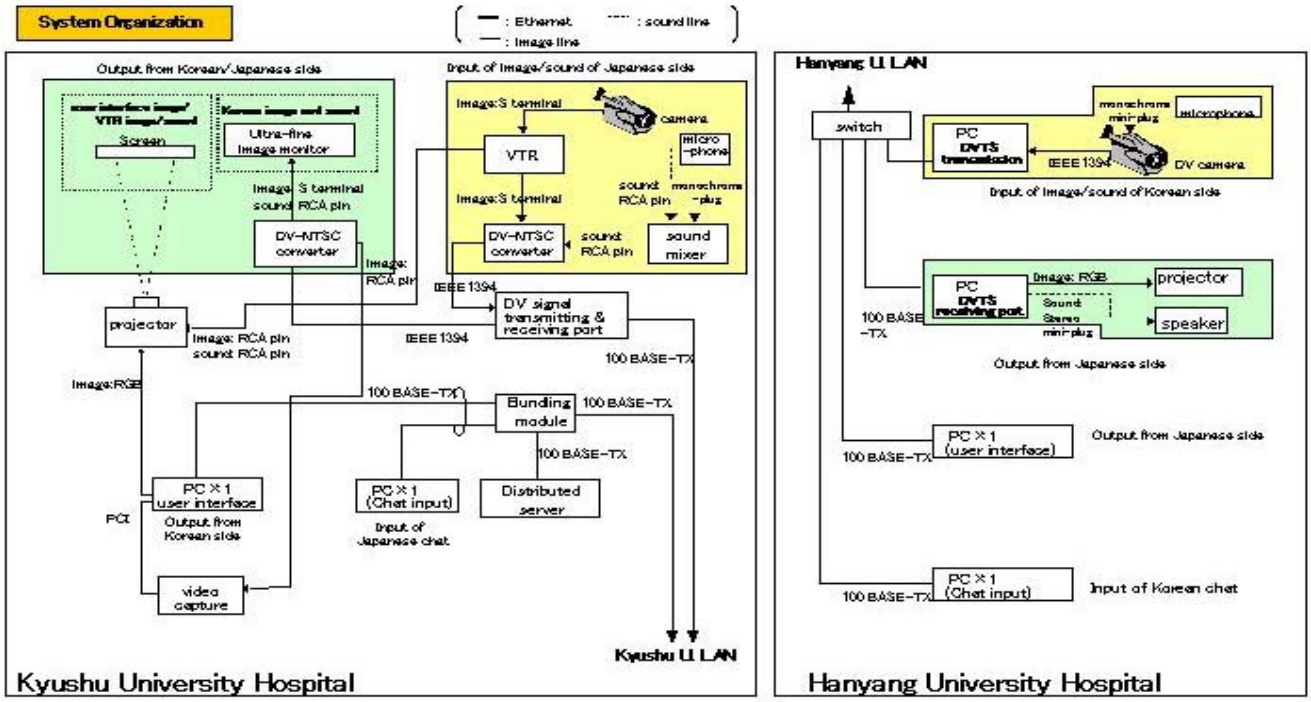

Fig3. Terminal systems organization

In Hanyang University Hospital terminal and Kyushu University Hospital terminal, we set up another monitor in each institute to show user interface of a translating chat using Korean-Japanese auto translator system (Fig. 4) [3].

Results

The recorded digital video of surgery was transmitted through a line of DVTS from Kyushu University Hospital to Hanyang University or National Cancer Center. The image of the audience in the conference room was transmitted to both directions through the other line. The audience discussed each other on the surgical procedures for about two hours at each conference. (Fig. 5)

The transmission of moving images with two lines of DVTS over Internet protocol was successfully performed. The patient history and preoperative images were also shown with still-images. The quality of the image was as good as the original digital video. The surgical anatomy was correctly identified and the procedures were well understood. The frame rate of 30 per second was obtained, and the movie was smooth and not sluggish. The sound was clear and there was little jittering during the entire course.

The time delay was less than 0.01 sec between both endpoints of the network.

Discussion

Various types of network has been possible for telecommunication. A triple ISDN line was popular in the field of telemedicine, but the maximum connection speed available was only 384 kbps [4]. Although ISDN was used for transmission of video endoscopies for cancer screening, it should not be appropriate due to possible insufficiency of the image quality for diagnosis [5]. While ADSL currently offers the transfer rate of 8 to 12 Mbps, it is still not satisfactory because the maximum capacity of the network defines the level to which the amount of data in a video stream has to be reduced. Low speed and noise are big interferences for telemedicine, and such impairments, which depend on the current network traffic, could appear with a certain frequency in ADSL. Network overload situations can therefore cause jerky movements and distortions of the image, and in extreme situations this can lead to a loss of information, image freezing, and breakdown of the whole video stream [6] [7] [8].

There have been many types of video compression technique, which were developed to make its transmission less stressful for the network [9]. The bandwidth of Moving Pictures Experts Group (MPEG) 1 or MPEG4 is as small as less than 1 Mbps, and the quality of image is unsuitable for medical use [10]. Although a more or less acceptable image quality was obtained with MPEG2 compression with necessary bandwidth of 8 Mb/s or more, any technical variation was found to cause a reduction in the overall image quality [8] [11]. On the use of these compressions, however, the process of data reduction has to be very fast to minimize the time delay it causes, and it should be associated with a minimum

Fig 4. The monitor shows the audience in Korean side in moving-images, contents for presentation in still-images, and translated sentences by an auto translation system.

Fig 5. Picture of video conference: The Fukuoka team discusses with the Korean counterpart with two video lines, broadcasting a recorded surgery and showing the audience.

information loss. The greater the compression needed, the grater the information loss and time delay that result.

The introduction of DVTS has opened a new and very exciting field of video transmission over Internet protocol. The system can be set up only with a digital video camera and a personal computer connected via an IEEE 1394 interface. There are many advantages. First, there was no detectable reduction in image quality between the original and transferred images. They can maintain exactly the same quality as originals, which is the most important factor in medical communication. Clear sound can also be preserved for discussion. Secondly, it can minimize the transmission delay, because DVTS requires no compression algorithm or complex process of encoding and decoding. In addition, the system is easily prepared and it costs less, because a commercially available digital video camera and a standard personal computer can be utilized. It is important to take in wider consideration, such as availability, flexibility, and cost as well as image qualification. Only disadvantage might be a need for very broadband infrastructures with about 30 Mbps for a single channel.

In accordance with increasing necessity of social communication between the two countries, the advanced infrastructure, KJCN, was newly constructed. A fiberglass connection transporting data at the speed of light was built up between Busan, Korea, and Fukuoka, Japan, providing a total bandwidth of 2 Gbps. The present project allowed exclusive reservation of up to 100 Mbps for two video streams, shielding the data from parallel transmissions of other projects competing for the same resources. The broadcast of high-quality medical movies with two DVTS streams was realized, for the first time, between the two countries.

Because of political boundary, medical communication was difficult between Korea and Kyushu area in Japan in spite of their close location. By using this new network system, however, we can communicate and exchange medical information over the national border without any stresses. In contrast that the knowledge of medical science is uniform and can spread via one-way transmission, information about medical techniques and healthcare concept are often unique in local regions and vary in areas and areas. The present system will help to remove a barrier of medical communications and to standardize them using high quality moving images.

Video transmission can provide much more information for medical education or conference, when compared with still-images. We fully agree with the need of DVTS as one option for video-based medical applications that will guarantee high-quality images and clear sound after transmission over a network. Teleconference of surgery is one of the suitable contents for high-quality communication. Small blood vessels or fine tissue structures need to be well recognized by the counterpart of audience. Endoscopy and pathological examinations are among other candidates, which similarly have to show delicate mucosal appearances or cell architectures. The principle that a medical content should be reached with the best image quality available should also be applied to telemedical applications. Any evident loss of information due to data transmission cannot be tolerated in medical fields.

We have established high-quality video transmission system over Internet protocol between Korea and Japan, which is easy to perform, reliable and economical. On the basis of the current results, the minimal requirement for digital video transmission for telemedicine is 30 Mbps with DVTS per channel. This will be a promising and very helpful tool of network for the two countries and worldwide remote medicine in the future.

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