DVTS Videoconferencing with Quatre
A Reasonable Tool for Medical Multipoint Applications

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Abstract. Digital video transport system (DVTS) is an economical but a very powerful tool in telemedicine, where image quality is a key for accurate diagnosis and adequate education. We have established this advanced system throughout Asia-Pacific area, and then successfully connected to Europe for the first time in August, 2007. We here summarize our current activity and will demonstrate an endoscopic procedure using a model stomach, connecting hospitals in Japan, Taiwan, Czech Republic, and several other European countries.

Key words: telemedicine, digital video transport system

1 Introduction

Although the use of videos is very helpful in medicine and there is no doubt that telecommunication is a great help for saving time and cost for exchanging information without any physical movement, telemedicine in general has not yet gained great popularity in clinical practice or medical education. One reason is that transmitted image quality was not high enough as required in medicine and another is because of the need to purchase special, costly, equipment to start it. Conventional systems using commercially available narrowband networks deal mainly with still pictures and are insufficient to send smooth moving images or video, which is frequently essential in surgery, endoscopy and other medical procedures and techniques [1-3].

With the digital video transport system (DVTS) over research and education network we have established a new system that can preserve original quality videos between remote hospitals thus can meet the requirements of medical providers in terms of both quality and economy [4-5].

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2 System and network

2.1 DVTS and its advantages

DVTS is a tool by which the digital video images can be directly transformed to an Internet protocol without any compression of motion images. Its basic technology is internationally qualified as DV over IP by the IETF (Internet Engineering Task Force) of ISOC (Internet Society). DVTS is freely downloadable software (http://www.sfc.wide.ad.jp/DVTS/) to be installed on a personal computer. The necessary bandwidth is 30 Mbps per channel and audio is transmitted simultaneously with the image [6].

DVTS has many advantages over conventional image transmission systems as such as:

1) It can completely preserve the quality of original motion images by avoiding compression processes.
2) Omitting these complex procedures can minimize the latency in transmissions between network stations as encoding and decoding of pictures is time consuming.
3) This system also allows use of common personal computers because there is no need to handle a complex algorithm.
4) The system is very simple; the digital image can be transmitted directly through IEEE1394 interface from the image source to a personal computer. We only need to connect the output of a camcorder or surgical instruments to a personal computer with DVTS installed and with sufficient Internet access.

2.2 Quatre and its mechanism

The more expansion we had, the more needs for multipoint connection arose [7,8]. The Quatre system (Information Services International-Dentsu, Ltd., Tokyo, Japan), specially designed for DVTS, functions similarly to the the H.323 Multi Point Control Unit (MCU), and meets this demands. Quatre running on Linux, optimizes high-speed movie processing and enables meetings between multiple remote sites with DV at extremely high quality.

Ordinary DVTS software is not equipped with many functions except for the transport of DV over the Internet because it was originally developed to demonstrate this communication protocol for DV over IP. While it does not matter when DVTS is used for one-on-one conversation, it becomes a significant problem when used for multi-site meetings since DVTS clients cannot simultaneously transmit DV data to several destinations. This requires other available technologies. To have a conference between four stations, for example, four IP addresses for DVTS and one IP address for monitoring are registered, and DVTS clients must send and receive DVTS data via Quatre rather than multicasting it directly to peers. After it receives DVTS data, it resizes each DV frame to a quarter of its original size using the Intel Xeon’s high speed command set, composes a DV stream from the four quarter streams and sends the data back to the remote sites (Fig. [1]).
Prior to 2003, high-speed Internet access for research and education from Japan to the United States and Taiwan had been available through Asia-Pacific Advanced Network (APAN) [9]. In 2003, a 1Gbps Internet service between Japan and Korea was started by Asia Pacific Information Infrastructure (APII) [10]. High-speed Internet access from Japan to China became possible in 2004 through National Institute of Information and Communications Technology (NICT) [11] and to Korea and China through APII, enabling experiments to be conducted with more partners in China. In 2005, Japan Gigabit Network2 (JGN2) [12] of NICT initiated high-speed Internet access to Thailand and Singapore. New activities with Singapore and Thailand were initiated that made use of these high-speed links.

Beginning in 2006, the Trans-Eurasia Information Network2 (TEIN2) [13] provided 620 Mbps links to NOCs in Singapore and Hong Kong, 150Mbps links to Malaysia and Thailand through the NOCs, and 45 Mbps links to Vietnam and Indonesia. The Philippines has also been connected at 150 Mbps via TEIN2. Australia is also successfully connected at 1 Gbps via the United States, and an additional 620 Mbps link with short latency is available through TEIN2.

Since high-bandwidth links of 620, 150 and 45 Mbps are available only to NOCs, the final obstacle is to improve local NOC connectivity to domestic Internet services.

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**Fig. 1. Schema of using Quatre system**

2.3 Network advancements in Asia-Pacific and to Europe
The Hong Kong NOC, for example, has many high-speed links, but because Hong Kong Academic and Research Network (HARNET) [14], a Hong Kong domestic Internet group does not connect to TEIN2 with sufficient speed, there are problems connecting to HKCU (Hong Kong Chinese University), despite the presence of a high-speed link to Japan. HKCU has a 1 Gbps link to China Science and Technology Network (CSTNET) [15], so our projects used this high-speed link for experiments with HKCU instead of the TEIN2 link. Also, in Singapore, Singapore Advanced Research and Education Network (SingAREN) [16] does not connect to TEIN2 NOC with adequate throughput, therefore the JGN2 link is used for experiments with the NUS (National University of Singapore). However, the throughput of JGN2 to Thailand is just 45Mbps, so even though there is no direct TEIN2 connection to Thailand from Japan, the TEIN2 link is sometimes used to provide higher bandwidth.

In 2007, the activities have been extended to the US and the EU. From Japan, Science Information Network3 (SINET3) [17] reaches Los Angeles and New York, most packets to US interior are delivered via Los Angeles and packets to the EU are delivered via New York. The bandwidth between Japan and the US and between the US and EU is 10 Gbps. Thus there is no problem with bandwidth.

In January 2007, India joined our activity. The network path from Japan to India is supported by Education and Research Network (ERNET) in India [18] which transits through the Italy NOC of GÉANT2 [19]. The bandwidth is 45 Mbps.

2.4 Patient privacy issues

Protection of patient privacy is of the utmost importance in telemedicine. To avoid the image to be stolen during its transmission over the Internet, the encryption of videos at live demonstrations is used. We use IPSec for this purpose as an IETF standard. VPN routers with support of IPsec (AR550S, AlliedTelesis K.K., Japan) are installed at every site. The throughput of the AR550S is about 100Mbps that can support three DVTS sessions at the same time.

3 Activities in Asia-Pacific region

Thanks to the recent development of domestic as well as international network infrastructures in the Asia-Pacific region, our new telemedicine system, which requires a high-speed network and was originally established between Japan and Korea, has expanded to 13 countries throughout the Asia-Pacific area. As of July 2008, over 140 telemedicine sessions (including real-time demonstrations and interactive teleconferences (Fig.3) were performed among 80 major institutions and meeting venues with the benefit of DVTS system. This is the first time that cutting-edge Internet technology has been applied to medicine on such a large scale [20][21]. We believe our videoconferencing system will have quite a substantial impact on medical education because healthcare providers in remote areas can have access to a high-quality view of a moving image equal to that of the original hospital. We also found this system extremely useful for teleconferencing in a routine clinical timeframe because there is only a few hours – time difference within all of Asia-Oceania.
Fig. 2. Internet Environment of our project

4 Expansion to Europe

We successfully connected to Europe for the first time to France and Germany in August 2007, to Italy in December 2007, and to Belgium in May 2008. Related details are summarized in Table 1 and shown in Fig. 4.

<table>
<thead>
<tr>
<th>Date</th>
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<th>European sites</th>
<th>Asian sites</th>
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<td>Hamburg, GR</td>
<td>TH, MY, TW</td>
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<td>Rome, IT</td>
<td>JP</td>
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<tr>
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<td>JP, SN</td>
<td>Endoscopy</td>
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* TNC, TERENA Network Conference; GR, Germany; FR, France; IT, Italy; BE, Belgium; TH, Thailand; MY, Malyasia; TW, Taiwan; CN, China; PH, the Phillipines; IN, India; JP, Japan; KR, Korea; SN, Singapore.
Fig. 3. Connected and to be connected stations

5 Demonstration at CESNET 2008

Supporting action to CESNET 2008 conference offers the first opportunity to connect the Czech Republic users with the benefit of our system. The main venue in Prague is to be connected to two hospitals in the Czech Republic (Central Military Hospital in Prague and Masaryk Hospital in Ústí nad Labem) and to two hospitals in Japan and a hospital in Taiwan via several networks with global dedication (GEANT, SINET, GLIF, APAN) and several national research networks (CESNET, REDIRIS, GARR, TWAREN). We will demonstrate an endoscopic procedure using a model stomach from Kyushu University Hospital in Japan. We will also give a tele-lecture from Kyoto University Hospital in Japan and a case presentation from National Taiwan University Hospital in Taiwan. Also Barcelona Clinical Hospital in Spain and University Hospital in ROME are preparing participation on this experiment.

Network configuration is as in Figure 5.

6 Conclusions

To make this telemedicine activity even more attractive, further development of supporting technologies is awaited. Quatre has been the only equipment we can use to establish multi-station teleconferences with DVTS, but it is only compatible with the NTSC format used mainly in Japan, Korea, US. To involve countries in Europe, China and many others in Southeast Asia using PAL format, we have had to use converters.
or to supply partners with NTSC cameras. In addition, demands for even better quality than the DV quality are increasing because various kinds of medical equipment with high-definition (HD) quality are now commercially available, including instruments for surgery and endoscopy. We have already reported a successful transmission of live surgery with uncompressed HD with 1.6 Gbps, but further effort is necessary to supply the necessary high bandwidth and to reduce the cost for special equipment [22].

We believe our cutting-edge system will facilitate the medical standardization beyond geographic borders using a high-speed academic network. Close cooperation between medical doctors and engineering staff is essential for success.

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