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Implementation and Experiments on Dependable Video Conference System

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1. Introduction

In this manuscript we describe the architecture of a dependable video conference system we have devised. Two techniques, convolutional-code-based FEC [1] and Xcast [2], are applied in this system. The former improves the probability that the information packets sent are received, and the latter reduces the number of packets transmitted in a multi-point conference. We implemented the proposed system and tested the implementation and functioning of the system over the Internet. We observed an improved QoS using an Internet simulator.

2. Overall system architecture

The proposed system is based on the ITU-T H. 323 system [3]. We modified the device called Gatekeeper (GK), which is based on the source list that is published by the OpenH323 Project [4], so that the RTP packets are transmitted through the GK. In this way, the GK at the sender generates redundant packets using (2, 1, *m*) convolutional codes with code puncturing [5], and then the lost RTP packets are recovered by another GK, as shown in Fig. 1. The convolutional-code header, including the sequence number and two length fields, is inserted between the UDP header and the RTP header of each packet. The use of two length fields allows the correct encoding and decoding of variable-length packets. The GK has buffers for not only the input packets but also for the output packets. The output buffer is for reordering the sequence of received or recovered packets. Dependable communications are thus achieved over the backbone networks without making changes to the terminals. We used Microsoft NetMeeting as the communication software of the terminals.

The GK has a function added to route Xcast packets, that is, forwarding the packets based on the list of destination addresses in the Xcast header. Furthermore, the Multi-point Control Unit (MCU) has been modified to create Xcast packets. In a multi-point conference, every terminal sends RTP packets to the MCU. The terminals send different data to each other, so Xcast cannot be applied to these packets. After receiving the data, the MCU combines the pictures and transmits the same data to all of the terminals. Then, Xcast is applied to reduce the traffic between the GKs.

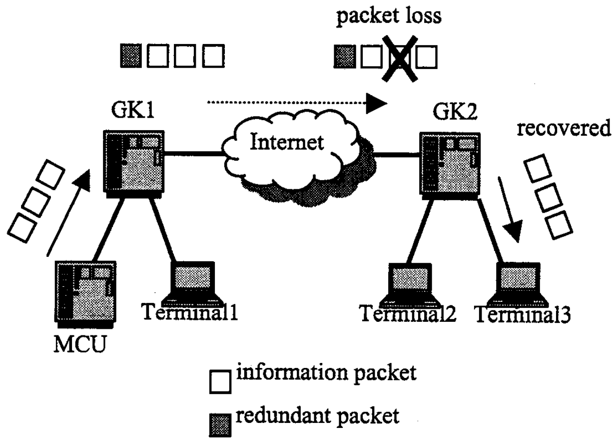

Fig. 1. Example of communication applying a convolutional code and Xcast.

3. Experimental results

3.1 Connectivity over the Internet

We implemented the GK and MCU for the proposed system on Linux, and tested the functioning and connectivity over the Internet. First, we held multi-point conferences between the networks of metro-u.ac.jp, toritsudai.jp, and iri.metro.tokyo.jp. Figure 2 shows the configuration of the network for the conference. The number of hops was at most 12, and the round-trip time was at most 120 ms between any pair of terminals. There was a NAT at iri.metro.tokyo.jp to use private IP addresses. In H. 323 system, some ports are opened after the connection is set up by using the IP address and port number information is contained in the control message. Thus, the use of private IP addresses stymies opening conferences because the IP addresses contained in the payloads of control packets differ from those in the IP headers. To solve this problem, we set up another NAT to assign the same IP address as the global IP address for the GK.

The sites toritsudai.jp and metro-u.ac.jp used global IP addresses, but there was a firewall at metro-u.ac.jp and it shut out any incoming packets except for those for communications invoked from inside of metro-u.ac.jp. Therefore, the terminals in toritsudai.jp could not connect to those in metro-u.ac.jp. When the MCU was set on toritsudai.jp, we confirmed that a multi-point conference between three sites, including up to five terminals, could be held, and that convolutional codes and Xcast worked correctly.

We also held conferences between toritsudai.jp and skku.ac.kr, setting two terminals for each site, as shown in Fig. 3. The number of hops was asymmetric, such as 14 (toritsudai.jp → skku.ac.kr) and 22 (skku.ac.kr → toritsudai.jp), and the round-trip time between these sites fluctuated between 150 to 600 ms. At skku.ac.kr, there was a firewall which rejected incoming packets. The one-to-one conference in which only the terminals

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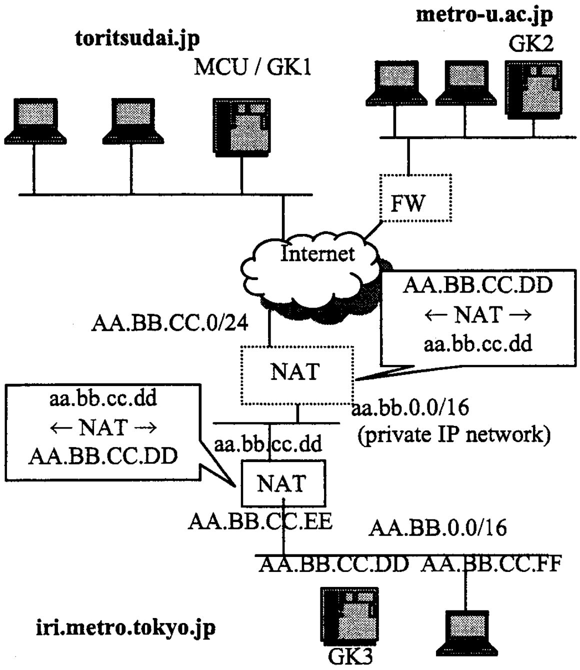

Fig. 2. Network configuration for an experiment. There are five terminals and three GKs in three sites. An NAT is set at iri.metro.tokyo.jp to use private IP addresses.

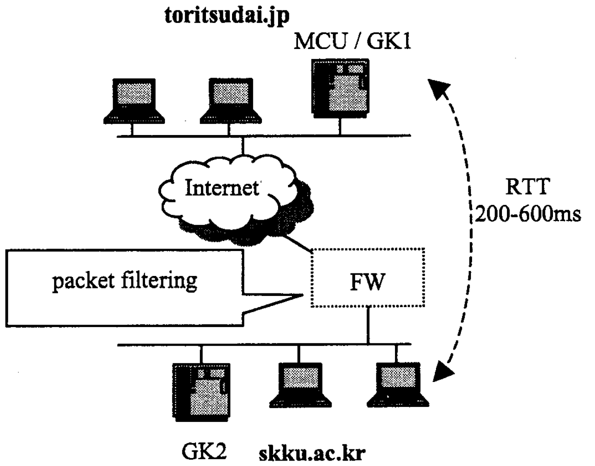

Fig. 3. Network configuration for an experiment between toritsudai.jp and skku.ac.kr.

are used without GKs failed. On the other hand, when the GKs redirected the packets, a connection was established between the terminals, even if neither of convolutional codes nor Xcast functions were activated. This was because different port numbers were assigned to the client (dynamically opened) port between Windows and Linux.

In this configuration, we confirmed the connectivity, but the quality of the transmitted picture appeared to be low quality (it also seemed to stand still). Because the packet-loss ratio was low during the conference, the use of convolutional codes did not seem to effectively improve the picture quality. Therefore, the low quality of the pictures was considered to be mainly caused by the fluctuation of delay time in the arrival of packets. In such cases, it might be effective if the buffer for the output packets at the GK has a function that not only reorders but adjusts the intervals.

Table 1. Measured PSNR between the pictures before and after transmission under packet-loss ratio 1%, 5%, and 10%. Three encoding schemes were applied.

applied code	PSNR[dB]			
	0%	1%	5%	10%
noConv	15.18	12.68	10.47	7.97
(2, 1, 3)	-	15.13	15.21	12.52
(2, 1, 7) (A)	-	15.17	15.12	14.36
(2, 1, 7) (B)	-	15.22	15.19	13.96

3.2 Evaluation of quality of transmitted pictures

We evaluated the quality of pictures that had been improved by using the convolutional codes. On the one-to-one conference via an Internet simulator, we transmitted a standard sequence of pictures and captured the pictures shown in the window of NetMeeting at the sender and the receiver. From these captured frames, we calculated the peak signal-to-noise ratio (PSNR). Table 1 shows the results of the PSNR for the standard sequence called "Football" (24-bit RGB, 125 frames). The applied convolutional codes had the same code rate, 3/4. The (2, 1, 7) convolutional codes (A) and (B) each had a different generator matrix. The size of the input buffer was set to $2 \times (m + 1)$, that is, 8 for the (2, 1, 3) convolutional code and 16 for the (2, 1, 7) convolutional codes. The table also shows the case where no redundant packets were sent. The convolutional code appears to have improved the quality of the motion pictures. With the (2, 1, 7) convolutional code (A), the degradation of the PSNR was no more than 1 dB even under the condition of a 10% packet loss ratio.

4. Conclusions

In this manuscript, we discussed our development of a dependable video conference system that uses convolutional-code-based FEC and Xcast. The system was realized by modifying the devices in the conventional system. We tested the functioning and connectivity of the system over the Internet between three sites in Japan, and between Japan and Korea. We evaluated the quality of transmitted pictures with respect to peak signal-to-noise ratio using the Internet simulator.

References

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