Uncompressed HDTV over IP Transmission System using Ultra-high-speed IP Streaming Technology

Keiji Harada, Tetsuo Kawano, Kazutaka Zaima†, Seiji Hatta, and Shigeyuki Meno

Abstract

In October 2001, NTT Laboratories developed the world's first "Uncompressed high-definition television signal (1.5 Gbit/s) over IP transmission technology." We are also developing operating systems for practical use. This article describes examples of the usage of this system and newly developed applications.

1. Introduction

In Japan, TV is moving from analog to digital format, as seen by the growth of broadcast satellite (BS) digital broadcasting based on HDTV[*1] and the imminent start of terrestrial digital broadcasting scheduled for later this year. Digital provides high-quality video, advanced functionality, and a larger number of channels, there are also increasing demands for systems that allow interoperability between computer and broadcasting networks, such as digital archives.

As transmission system and computer network connectivity becomes a reality. NTT Laboratories, in October 2001, developed technologies that enable long-distance transmission of 1.5-Gbit/s HDTV signals over an IP network. NTT Laboratories also developed video transmission applications for utilizing and extending ultra high-speed IP streaming technology, with the ultimate aim of improving transmission and broadcasting efficiency and making advanced use of video materials.

2. System overview and technology

System overview

The uncompressed HDTV over IP transmission system converts HDTV and SDTV[*2] video signals to IP packets and transmits them in real time over an IP network. An overview of the system is shown in Fig.1. Because the video signal requires no compression and decompression, there is little delay, and high-quality video can be displayed after transmission. This system also supports multipoint connections to multiple nodes, providing infrastructure for a wide-scale system that is independent of distance or limitations on the number of nodes. The IP-based transmission allows standard IP transmission equipment to be used.

Technology

This system uses an expanded layer 2 protocol called POS++ implementing POS (Packet Over SONET/SDH[*3]). POS++ uses 64-kbyte payloads[*4] for optimal high-speed IP transmission. Video frame loss and packet size relationships for HDTV data are shown in Fig. 2. By using POS++ 64 kbyte packets, a packet loss ratio of approximately 1×10^{-9} was

† NTT Network Service Systems Laboratories
Musashino-shi, 180-8585 Japan
E-mail: zaima.kazutaka@lab.ntt.co.jp

*1 HDTV (High Definition Television): uses a 16:9 standard aspect ratio. The bit-rate of uncompressed HDTV data is approximately 1.5 Gbit/s.

*2 SDTV (Standard Definition Television): uses a 4:3 standard aspect ratio. The bit-rate of uncompressed SDTV data is approximately 270 Gbit/s.

*3 SONET/SDH: a layer 1 standard. It is a highly reliable optical network used in high-speed leased lines and telephone trunk lines. There are standards for different bandwidths, such as 622 Mbit/s, 2.4 Gbit/s, and 10 Gbit/s.

*4 Packets are composed of headers and payloads. Headers contain information such as destination addresses. User data contains payload. For POS++, the maximum packet size is 64 kbytes, making it a highly effective means of transmission, as it does not require disassembling or reassembling IP packets.

achieved. For protocols with small packet sizes, such as Ethernet (1500 bytes), satisfactory performance can't be expected because IP packet division and reassembly processes increase the total processing load on end node. POS++ is a key technology for achieving HDTV over IP transmission without compression.

System features

The system has the following three major features.

(1) Uncompressed video signal and long-distance Transmission

Uncompressed, long-distance, multipoint transmission is possible for HDTV and SDTV signals. Currently, video materials are general-

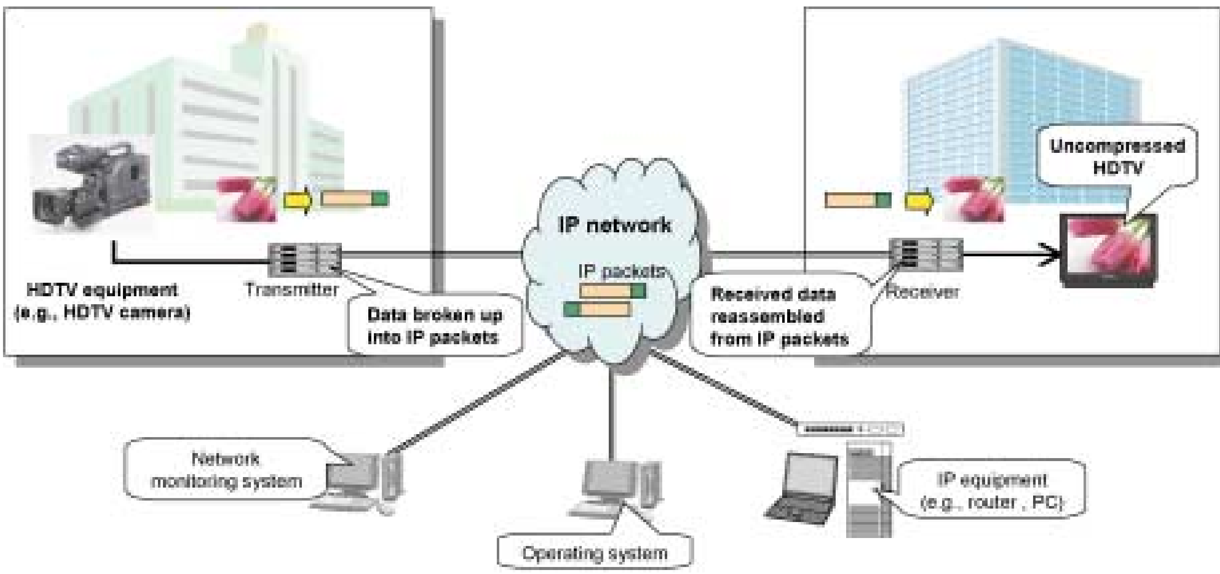


Fig. 1. System overview.

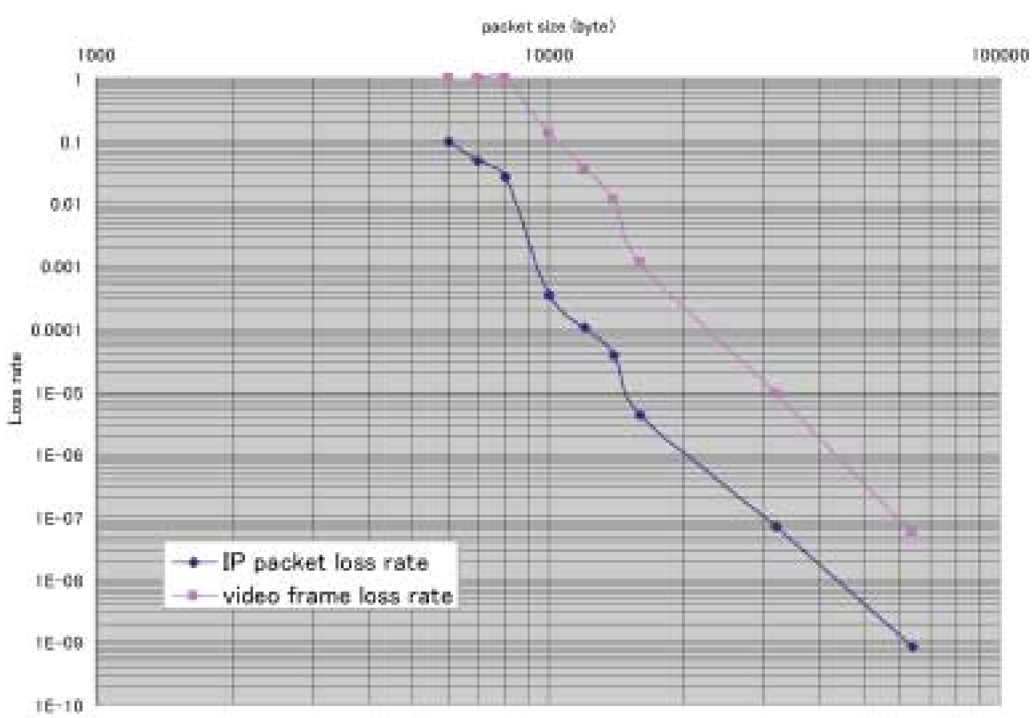


Fig. 2. Relationship between frame loss rate and packet size.

ly transmitted over ATM networks after being compressed or stored on video tapes or other media and physically shipped to their destinations. However, physical shipping takes time, and compression and decompression lead to image degradation*5. Because this system achieves long-distance forwarding of uncompressed video signal, it is very suitable for forwarding video materials.

(2) Flexible expansion options

Through integration with other IP equipment, a variety of additional features can be supported. IP transmission equipment is readily available on the market, and additional features such as equipment monitoring and management can easily be implemented. NTT Laboratories have also added features such as system monitoring and management from personal computers using Web browsers on the same IP network. This simplifies the development of management systems using graphical user interfaces

*5 For transmission by ATM, video data is usually compressed to approximately 150 Mbit/s or lower. Even when saving to media, there may be image degradation due to compression. When coaxial cable is used, there is no need for compression or decompression, but the coaxial cable standards limit cable length to 100 meters.

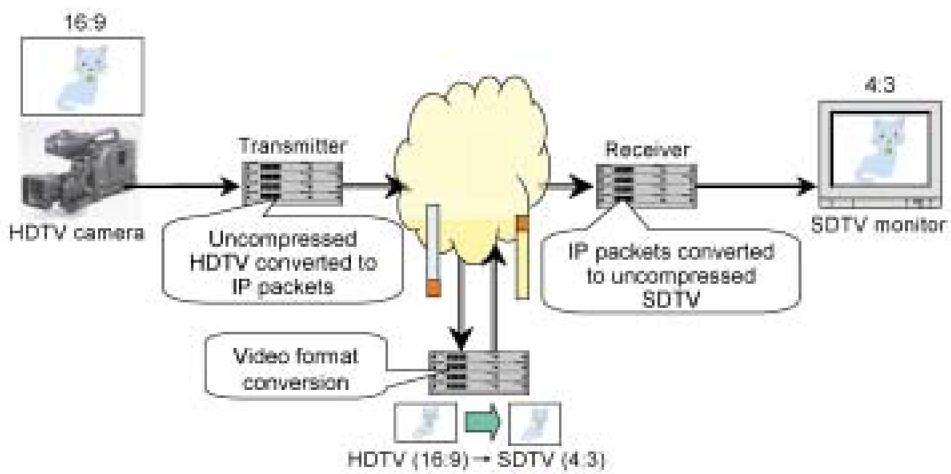


Fig. 3. Format conversion.

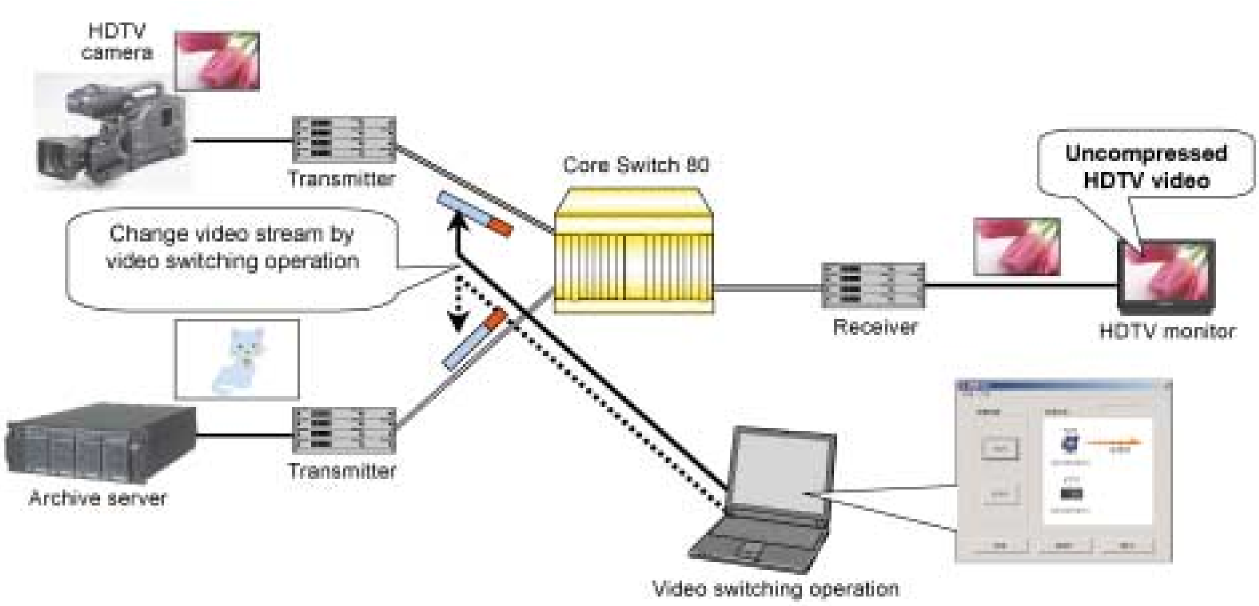


Fig. 4. Video switching application.

Fig. 5. Distance lecture using uncompressed HDTV transmission system.

tailored to operator work requirements, and vastly reduces development and integration costs. Adding these management features makes it possible to create a high-quality video network that can be used easily. This system has the possibility of being the best system for producing and editing broadcasting programs efficiently and of creating new ways of using video materials.

(3) Application examples

This system uses software processing using standard equipment, giving it superior expandability. System customization and application expansion, as shown in the following examples, are simple.

• Format conversion

The video format of signals can be converted to match that of the attached equipment. As Fig. 3

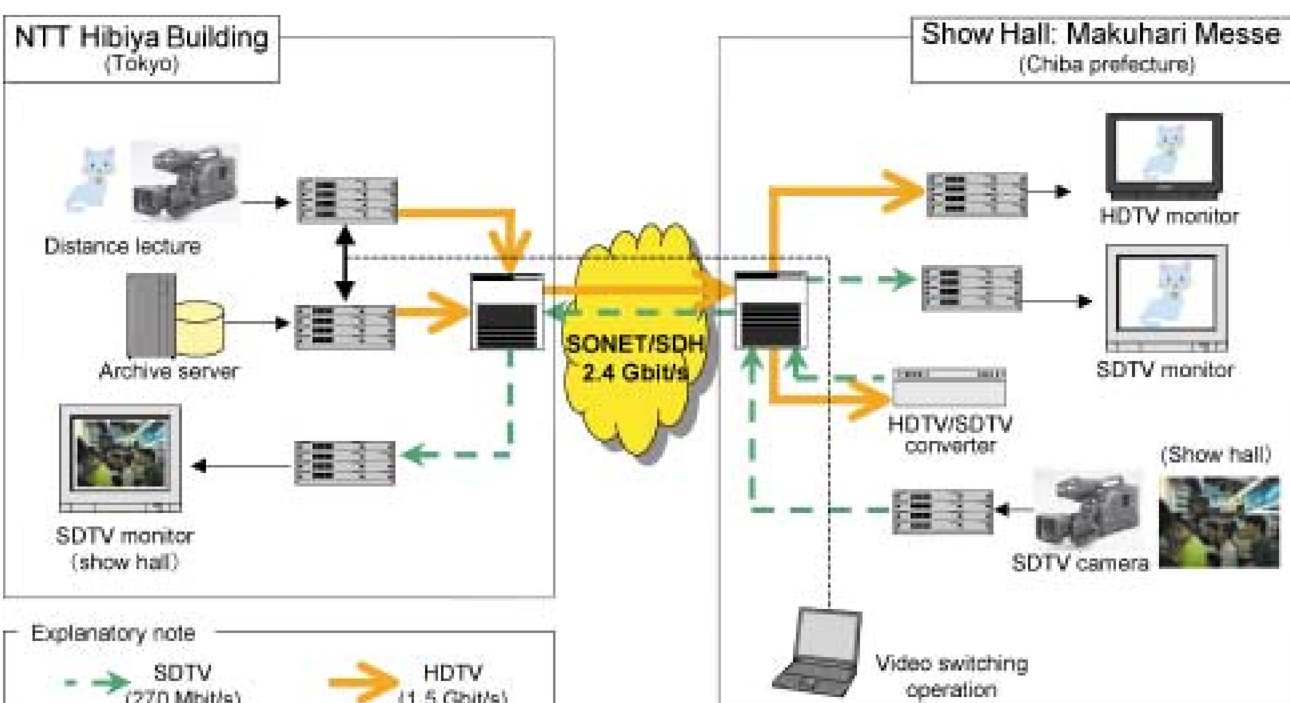


Fig. 6. Demonstration system used at NETWORLD+INTEROP 2002.

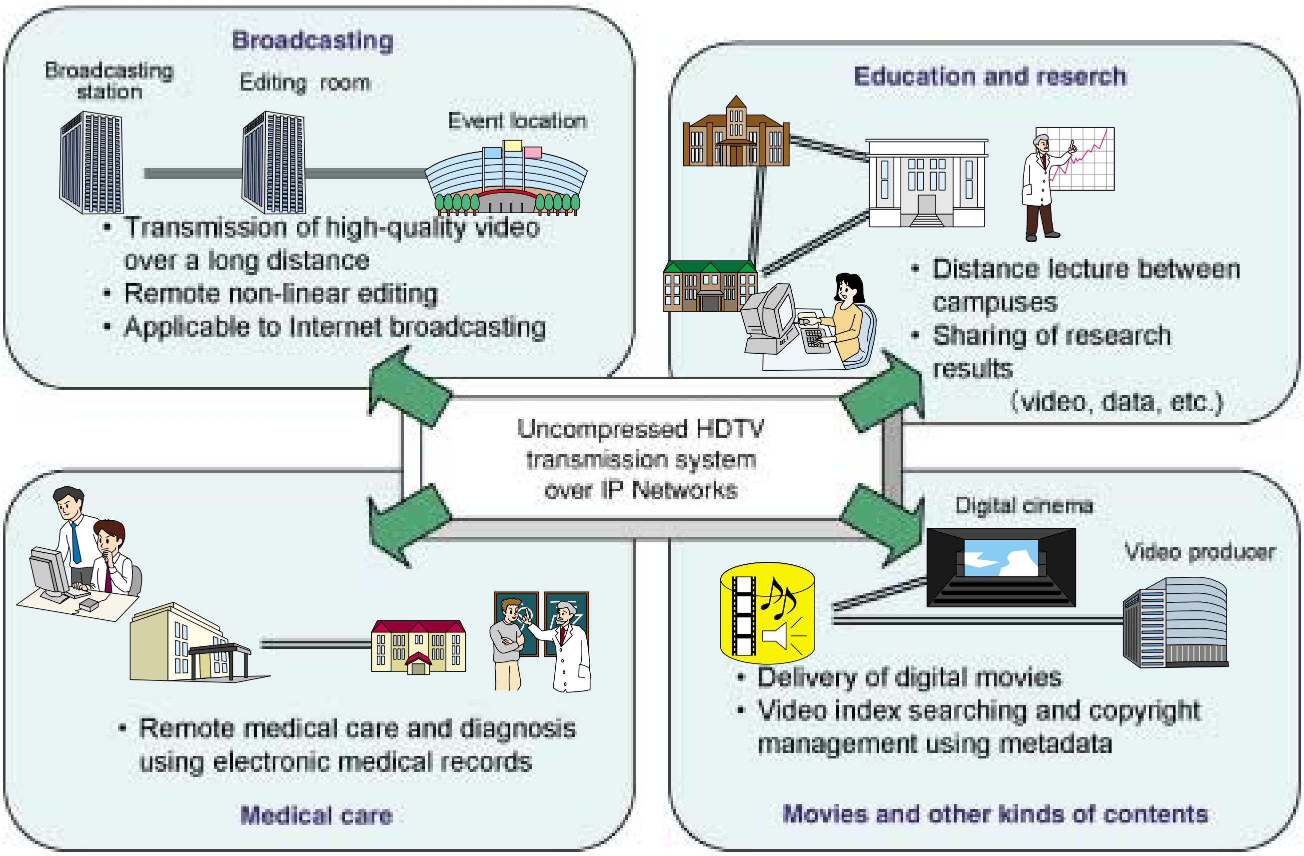


Fig. 7. Applications in the future.

shows, HDTV signals can be converted by IP network devices to SDTV signals, and resent as IP packets. Automatic format conversion, simultaneous transmission to multiple nodes, and simultaneous SDTV/HDTV signal transmission can be managed by the operation system.

• Video switching

The video signal can be seamlessly switched without changing the physical configuration of the receiving equipment. Figure 4 shows the operation system can switch video streams from the video archive server to a camera output signal.

3. Implementation examples

At the "NETWORLD + INTEROP 2002 TOKYO" show, held in July 2002, two extended applications were used at the NTT Communications booth for a demonstration of this system. The show site, Makuhari Messe, was connected to the NTT Hibiya Building, and a lecture was sent from the Hibiya Building, with the materials of lecture, as the "HDTV Long Distance Seminar" booth demonstration (Fig. 5). The equipment at the NTT Hibiya Building was controlled remotely from Makuhari Messe. The structure of the demonstration system is shown in Fig. 6. NTT presented advanced technologies, and we were praised by the attendees including ones from the broadcasting field.

4. Concluding remarks

In the future, we intend to: i) produce more advanced video transmission systems through additional development and field testing, ii) implement video searching and video sharing systems using metadata for unified video contents management and copyright protection system, and iii) develop a more convenient network for video, combining compressed video transmission technologies and uncompressed video transmission technologies (Fig. 7).

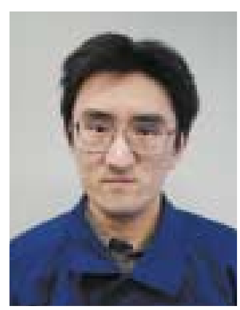
In the future, we hope that these video systems will be used not only for the broadcasting field, but also for remote medical and diagnostic use, digital cinema transmission, computer graphics (CG) production, and other fields that can make optimal use of superior system performance. We will research the construction technologies of higher-value-added video transmission networks.

Kazutaka Zaima
Research Engineer, Integrated IP Service Innovation Project, NTT Network Service Systems Laboratories.
He received his B.E. and M.E. degrees from Yamaguchi University, in 1991 and 1993, respectively. He joined NTT in 1993 and engaged in development of "π-system" and "super-high-speed common carrier leased line". Currently he is engaged in the research on SDH transmission system. He is a member of the Institute of Electronics, Information and Communication Engineers.

Keiji Harada
Senior Research Engineer, Supervisor, Integrated IP Service Innovation Project, NTT Network Service Systems Laboratories.
He received his B.E. degree from Nagoya Institute of Technology, in 1987. He joined NTT in 1987. Currently he engages in the research on SDH transmission system. He is a member of the Institute of Electronics, Information and Communication Engineers.

Seiji Hatta
Member, Integrated IP Service Innovation Project, NTT Network Service Systems Laboratories.
He received his B.E. and M.E. degrees from Kyushu University, in 1991 and 1993, respectively. He joined NTT in 1993 and is engaged in the development of "Video Distribution System". Currently he is engaged in the research on SDH transmission system.

Tetsuo Kawano
Research Engineer, Network Intelligence Laboratories, NTT Network Innovation Laboratories.
He received his B.E. degree from Kumamoto University, Japan in 1991. He received his M.E. degree and Ph.D. from Kyushu University, in 1993 and 1996, respectively. He joined NTT Laboratories in 1996. Currently, he is studying fast-protocol processing system architectures. He is a member of the Institute of Electronics, Information and Communication Engineers.



Shigeyuki Meno
Member, Integrated IP Service Innovation Project, NTT Network Service Systems Laboratories.
He received the B.S., degree from Keio University, in 1996. In 1996, he joined Tokyo development center, NTT Corporation. Currently he is engaged in the research on SDH transmission system.