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Nippon Telegraph and Telephone Corporation

NTT Communications Corporation

Keio University

Tokyo University of Technology

Mitsubishi Electric Corporation

**World's First Trans-Pacific and Trans-Atlantic (21,000km) Real Time  
Switching and Streaming Transmission of Uncompressed 4K Motion  
Pictures**

**Live 4K images of 23rd Kyoto Prize Events Streamed from Kyoto to Stockholm via  
Chicago**

**Tokyo, November 20, 2007** – Five digital media pioneers in Japan -- Nippon Telegraph and Telephone Corporation, NTT Communications Corporation, Keio University, Tokyo University of Technology, and Mitsubishi Electric Corporation -- jointly demonstrated the world's first real time glitch-free switching of super-high-definition (SHD) uncompressed 4K digital video sources (6 Gbps per source) on IP networks and their live distribution over the Pacific Ocean and the Atlantic Ocean (from Kyoto to Stockholm via Chicago). 4K motion pictures with 8 million pixels per frame has 4 times higher resolution than HDTV. This demonstration also confirmed the potential capability of multicasting compressed 4K video streams (500Mbps) to thousands of destinations, 4K video stream encryption, and real time decryption at the destination.

Kyoto Prize (\*1) events were held on Nov. 10 and 11. 4K digital motion pictures were captured using multiple 4K digital video cameras in Kyoto. The 4K video streams were switched glitch-free over the 10Gbps IP network and immediately transmitted to Stockholm via Chicago as uncompressed 4K image sources (6 Gbps). Also, live compressed 4K motion pictures (\*2) (500 Mbps) were multicasted(Figure 1).

This proves that SHD 4K digital images can be produced, recorded, encoded, switched, and delivered on the fly over IP networks world-wide. These technologies will be put into practical use in the fields of academia, education, medicine, as well as cultural activities. Some of the experiments were conducted in the course of “research and development of the next generation video contents production and distribution

technologies” supported by the Japanese Ministry of Internal Affairs and Communications and using the JGN2 (\*3) network operated by the National Institute of Information and Communications Technology (NICT). Keio University participation was also supported by funds for the promotion of science and technology from the Ministry of Education, Culture, Sports, Science and Technology. International collaboration for this project was made possible, in part, by the participation of Keio University and NTT in the CineGrid international research consortium for networked digital media experimentation.

## 1. Content of experiment

### A) Real time editing and transmission of live 4K digital images over the network

At the Kyoto International Conference Center, multiple 4K live motion pictures captured by using 4K digital video cameras were encapsulated into uncompressed IP packet streams (6 Gbps per stream) without deterioration of image quality or significantly increased latency. These multiple live streams were switched over the network into a single uncompressed live stream, and immediately transmitted to Stockholm via 10 Gbps Ethernet connections over 21,000 km (Figure 2). This world’s first live switching and oversea transmission of uncompressed 4K images was successfully demonstrated by connecting the Layer-Two (Ethernet) facility from Kyoto to Stockholm via Giga Stream Private Line provided by NTT Com, and various Global Lambda Integrated Facility (GLIF) resources such as JGN2 (Trans-Pacific), CESNET (Trans-Atlantic), SURFnet and NORDUnet. The success of this experiment also demonstrated the importance of lambda networking paradigm pioneered by the international GLIF community. (<http://www.glif.is>)

The key technical features are;

- The Research Institute for Digital Media and Content (DMC) of Keio University supervised the 4K camera work, real time image switching, and image processing work flows based on their recent research activities in SHD 4K image content applications.

NTT and NTT Com developed a real time switching system for uncompressed 4K images, and successfully demonstrated image selection by remote switching without causing congestion between multiple live image streams in the network(Figure 3).

### **B) 4K multicast streaming scalable to thousands of destinations**

During the Kyoto Prize events (Nov. 10 and 11), the live 4K video stream (6 Gbps) supervised by Keio University's DMC team was compressed using a real-time JPEG2000 codec (\*4) to 500 Mbps, and distributed via IP networks to four destinations including Stockholm (Figure 1). Multicast distribution was realized by employing the Flexcast technology (\*5) which allows stream duplication in a network that does not directly support IP multicasting. NTT developed a hardware-based Stream Duplicator with a throughput of 10Gbps which allows a 4K stream to be duplicated into at least ten streams. For the experiment, three Stream Duplicators were installed sequentially in the network, and successfully demonstrated the capability of distribution to thousands of destinations via three-stage duplication by employing a newly developed protocol for load balancing between the Stream Duplicators.

### **C) Secure 4K multicast streaming with encryption**

Preserving digital content quality and protecting the intellectual property rights are indispensable features for 4K Digital Cinema content delivery via IP networks. In this experiment, Tokyo University of Technology sourced 4K Computer Graphics (CG) images for quality testing. After off-line encryption, the test images were distributed in real-time via Flexcast Stream Duplicators and then successfully decrypted on-line at each destination by real-time 4K decryption hardware newly developed by Mitsubishi Electric Corporation. This proves that cinema theaters with digital cinema projection systems, which today are designed for disk-stored digital content, can also be used for playing non-cinema digital content, with both high quality and high security even if delivered via real-time 4K streaming technology.

## **2. Future plans**

NTT, NTT Com, Keio University, Tokyo University of Technology, and Mitsubishi Electric Corporation plan to jointly advance research related to the distribution and production of high-quality digital contents by using a high-speed networks, as well as on application technologies in the fields of education, medicine, entertainment and culture.

### 3. List of the organizations who collaborated in the above experiments

Venue and Contents: Inamori Foundation  
 4K Digital Recording System: Keisoku Giken Co.,Ltd  
 Equipment and Network: JGN2, T-LEX, StarLight, TransLight/StarLight, CESNET, NetherLight, SURFnet, NORDUnet,, SARA, The University of Tokyo, KTH (The Royal Institute of Technology, Stockholm)

● Figure 1. Experimental network for 4K real-time image switching and distribution

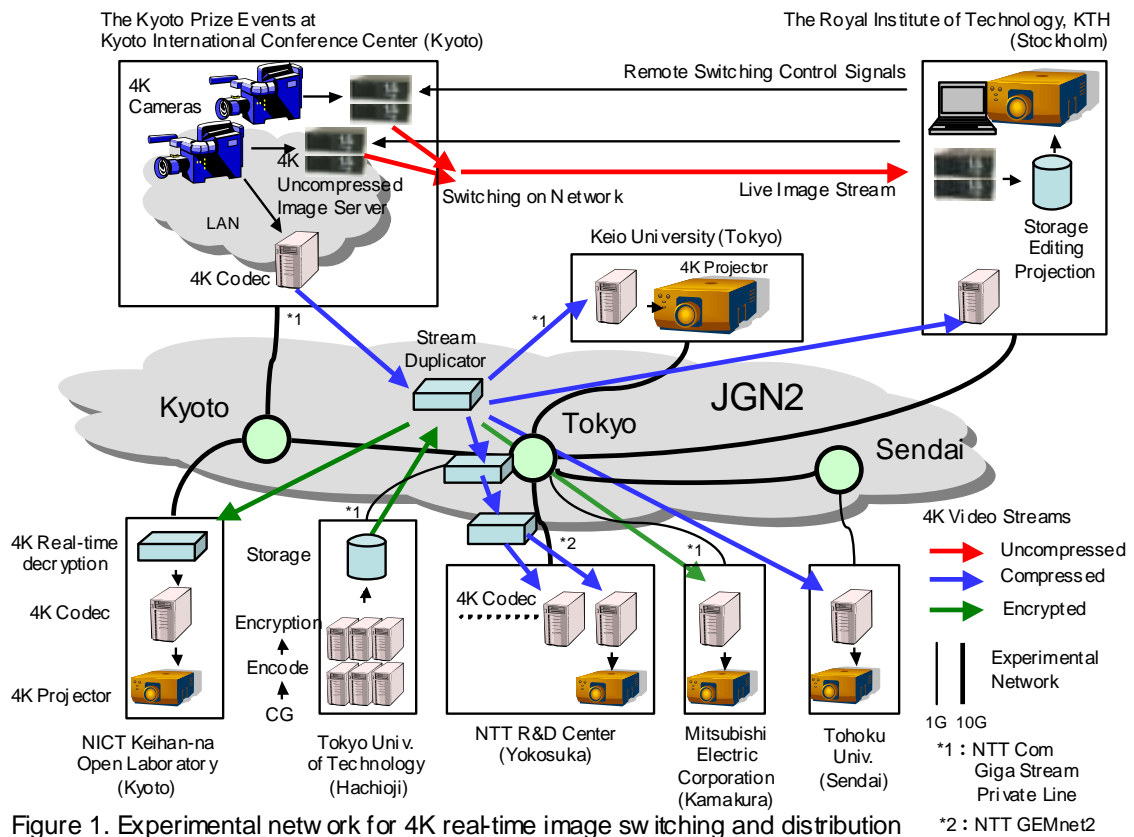


Figure 1. Experimental network for 4K real-time image switching and distribution

- Figure 2. Japan-US-Sweden route for uncompressed 4K video live streaming

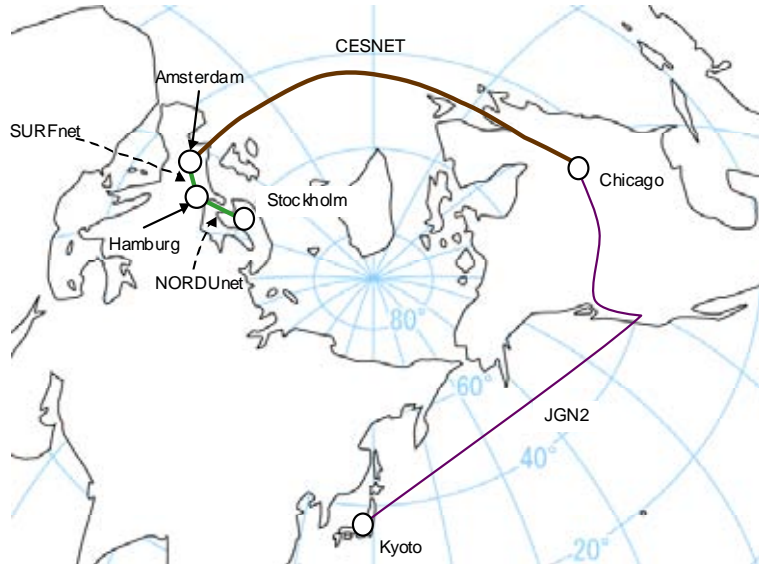


Figure 2. Japan-US-Sweden route for uncompressed 4K video live streaming

- Figure 3. On-line switching of uncompressed 4K images on the network

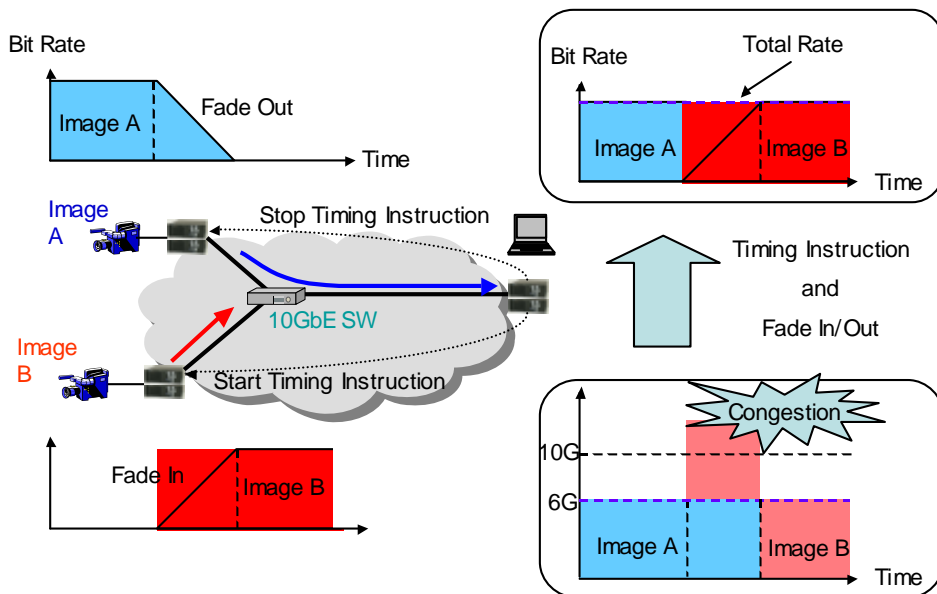


Figure 3. On-line switching of uncompressed 4K images on the network

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## **Terminology**

\*1 Kyoto Prize

The Kyoto Prize, awarded annually since 1985, is an international award to honor those who have contributed significantly to the scientific, cultural, and spiritual betterment of mankind. The Prize is presented annually in each of the following three categories: Advanced Technology, Basic Sciences, and Arts and Philosophy. The Prize is managed by the Inamori Foundation founded in 1984 by Kazuo Inamori (now Chairman Emeritus of Kyocera Corporation).

#### \*2 4K Digital Cinema

Recommended standard developed by DCI (Digital Cinema Initiatives, LLC) established by the six major Hollywood studios for future digital cinema theatrical distribution and currently being formalized by the Society of Motion Picture and Television Engineers (SMPTE). 4K refers to the number (4096) of horizontal pixels. The DCI also selected JPEG2000 compression (\*4) for digital cinema distribution. A 4K image frame of eight million pixels (4,096 by 2,160 pixels) at uncompressed bit rate of 6 Gbps is compressed to no more than 250Mbps for digital cinema distribution. However, for this experiment, a bit rate up to 500 Mbps was used for higher quality such as might be appropriate for contents beyond traditional theatrical-release feature movies, such as live music concerts, sports, and cultural events, generally referred to as ODS (Other Digital Stuff) in DCI terminology.

#### \*3 JGN2 (Japan Gigabit Network 2)

Research and development testbed network that has access points in all Japanese prefectures as well as in the United States. The National Institute of Information and Communications Technology (NICT), an independent administrative legal entity, started operation in April 2004. NICT's purpose is to activate the Japanese economy and enhance the competitiveness of Japan by accelerating the development of Next Generation Advanced Networks through the cooperation of industry, academia, and government bodies.

#### \*4 JPEG2000 codec

JPEG2000 is an image compression encoding method to reduce the amount of digital information frame by frame. It offers excellent quality though its compression rate is lower than MPEG which exploits the correlation between frames to further reduce data rate. A JPEG 2000 codec also describes any device which encodes or decodes digital image signals using the high-quality encoding method called JPEG2000.

#### \*5 Flexcast technology

A method to construct routing autonomously on the usual IP unicast network and to achieve multicast functionality via networks that do not support any IP multicast protocol. Gradual introduction is possible in accordance with the growth of traffic and evolving business strategies. NTT Network Innovation Laboratories developed this technology, and it is being used in the "Live Spark" video distribution system product from NTT Advanced Technology Corporation.