Successful Demonstration of Simultaneous Wide-area Multipoint Transmission of High-definition Streams for the Broadband Ubiquitous Era—The World's First Large-scale Confirmation of Broadband Content Distribution by End Users

The Telecommunications Advancement Organization of Japan (TAO) and NTT succeeded in jointly demonstrating multi-origin, multi-program simultaneous content distribution of high-definition(HD)-class IP streams on May 15, 2003. The experiment was conducted on the Japan Gigabit Network (JGN*1), a research network operated and administered by TAO, and the streams were transmitted using Flexcast, which is multipoint transmission technology developed by NTT, and TAO's load balancing technology (details are described later). It involved more than twenty video receivers located at four TAO-owned research facilities.

The experiment was carried out by TAO Makuhari Research Center and NTT Network Innovation Laboratories using an IP network constructed by linking MPLS*2 routers via JGN. One goal was to verify the potential of wide-area multipoint stream distribution, specifically to prove the feasibility of simultaneous multipoint distribution of high-volume IP streams generated by end users.

Prior to this trial, only simultaneous distribution of single HD streams to a few sites on Internet2*3 based on IP multicast technology had been reported. This trial is the world's first to achieve simultaneous distribution involving multiple sources and several tens of destinations. As such, it opens the door to the full-scale distribution of high-volume streaming contents from end users, which presages the broadband ubiquitous era.

The experiment verified capabilities and identified issues requiring further study with regard to (1) transmitting technologies (Flexcast*4) to handle extensive multiple areas and (2) quality-of-service (QoS) technologies based on dynamic load balancing that suit MPLS routers. There were two main achievements.

(1) Simultaneous transmission of HD-class (25-Mbit/s) IP stream contents from three servers to more than twenty receivers at four sites, while minimizing the load on networks and servers.
(2) Equalization of network usage by autonomously switching a path between two sites, when two independent paths were prepared and the server traffic was increased to produce congestion. This proved the effectiveness of the dynamic load balancing among MPLS routers to maintain quality and high-volume IP stream distribution.

The experiment confirmed the successful resolution of the image distortion problem, caused by excessive loading of the streaming servers or insufficient bandwidth, which previously hindered high-volume IP streaming from end users. Thus, users can

*1 JGN (Japan Gigabit Network) is an open testbed administered and operated by TAO to conduct R&D on high-speed networking and high-performance application technologies such as next-generation Internet technology. JGN has been open to both public and private entities for five years since 1999, providing a wide range of research opportunities. For details, see http://www.jgn.tao.go.jp/english/index_E.html
(1) Ultrahigh-speed optical-fiber networks with links up to 2.4 Gbit/s and 66 access points covering all prefectures in Japan.
(2) Five shared-use research facilities (Gigabit Laboratories)
(3) Ten research centers have been established by TAO to perform its own research.

*2 MPLS (Multiprotocol Label Switching) is a packet forwarding framework standardized in the Internet Engineering Task Force, which integrates ATM-like label swapping with network-layer routing. In MPLS, packets are fast-forwarded at each router according to short labels attached by the ingress router. This avoids the slow process of consulting IP headers.

*3 Internet2 is a consortium lead by over 200 universities working in partnership with industry and government to develop and deploy advanced IP network applications and technologies (http://www.internet2.org/).

*4 Flexcast (Flexible Stream Multicast) independently constructs the best transmission route by adapting to traffic variations as triggered by user requests. This is an autonomous large-area multipoint transmission technology that can automatically construct and maintain optimal delivery trees as the number and location of transmitters and receivers changes and as IP network routing changes. Flexcast was developed by NTT.

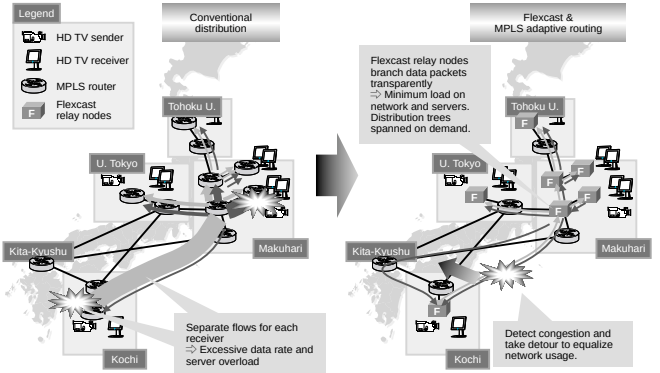

Fig. 1. Overview of the experiment.

receive images whose quality equals that of the original material. This will lead to the streaming distribution of motion pictures and videos with high quality, which will satisfy sophisticated audiences anywhere and anytime.

Overview of the experiment (Fig. 1)

(1) Network configuration
- TAO's Makuhari and Kochi Research Centers (RCs) and Annexes of Tohoku Univ. and the Univ. of Tokyo were connected via JGN (OC-3, 155 Mbit/s) using MPLS routers. Multiple Flexcast relay nodes were installed in each site.
- Multiple HD decoders were set up in each site, more than twenty in total.

(2) The applicability and effectiveness of the transmitting technology supporting extensive multiple areas (Flexcast) was verified.
- HD streaming sets were placed in Makuhari and Kochi RCs and an HD camera was placed in the Univ. of Tokyo Annex. UDP (user datagram protocol) video streams from these three sources were transmitted simultaneously by Flexcast.
- The number of receivers at sites was increased randomly and multicast distribution trees were built autonomously.
- Flexcast was confirmed to use less bandwidth, whereas the network usage in conventional distribution using multiple unicast flows increases in proportion to the number of receivers.

(3) QoS technology based on dynamic load balancing using MPLS routers was verified.
- When congestion was intentionally created on communication links by introducing multiple HD streams, MPLS routers autonomously switched to a detour path to equalize network usage and successfully maintained the quality of the HD streams.

Future plans

Based on the results of this experiment, we intend to establish technology for IP-based high-volume wide-area multipoint stream transmission that can be used easily by everyone. We will consider business- and service-related issues regarding its application.

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