UHDTV IP multicast distribution experiments using MPEG-H MMT

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Abstract—We have conducted IP multicast distribution experiments using MPEG-H MPEG Media Transport (MMT) in managed CATV networks to promote 4K/8K UHDTV. In this paper, we report an experiment in which we uplinked 4K/8K UHDTV content to an internet exchange (IX) through existing dedicated lines and facilities, and then conducted multi-channel distribution simultaneously through commercial fiber to the home (FTTH) lines provided by CATV managed networks. We confirmed that the UHDTV contents could be received by prototype STBs through the FTTH environment. The experimental result shows the possibility of commercializing nationwide simultaneous and multi-channel distribution of UHDTV contents through existing IP network facilities.

I. INTRODUCTION

MPEG-H MPEG Media Transport (MMT) has been standardized by the ISO/IEC as a new IP-based media transport scheme [1]. We have been verifying IP multicast distribution technology using MMT to realize integrated broadcast and broadband (IBB) services and to expand 4K/8K UHDTV distribution in CATV networks.

Currently, UHDTV content is distributed by sending it to a CATV operator via a dedicated network, such as a satellite or CDN (Content Delivery Network), and then connecting to fiber to the home (FTTH) access networks via CATV facilities. MMT has been adopted for ISDB-S3 (Integrated Services Digital Broadcasting for Satellite, 3rd generation: ITU-R Recommendation BO.2098). In Japan, ISDB-S3 has been actively used since December 2018 for new 4K/8K UHDTV satellite broadcasting [2].

When an IP multicast scheme is used to deliver MMT streams from broadcasting stations to home receivers via to FTTH network of a CATV operator, low latency distribution of 4K/8K UHDTV could potentially be enabled using existing FTTH networks and facilities by IBB services through multi-channel distribution. Therefore, we have conducted IP multicast distribution experiments using MMT in managed CATV networks, uploading multiple live UHDTV videos to an internet exchange (IX) operator to experimentally evaluate large-scale distribution without using a public CDN.

II. IP MULTICAST DELIVERY BY MMT

MMT is a new media transport system that can be adopted to various transmission paths such as satellite broadcasting, terrestrial broadcasting, and the Internet [3]. It has been used for the new 4K/8K satellite broadcasting system and is also being considered for application to a next-generation terrestrial broadcasting system [4]. MMT is an IP-based protocol that has an advantage of easier signal handling, which simplifies IBB services.

In addition, MMT sends presentation timestamps, which allows synchronous presentation between different transmission paths, seamlessly switching between broadcast and communications, and complementing the error packets of broadcast with packets from broadband [5].

To realize new services such as multi-view 4K/8K UHDTV, we conducted an IP multicast delivery experiment using MMT in a managed network environment where IP multicast is highly feasible. This experiment is categorized as a linear service that allows service providers to configure transmission timing within the managed network. In Japan, a new 4K/8K satellite IP rebroadcast scheme, MMT packets are divided and transmitted using IP over TS scheme with the same fixed length as MPEG-2 TS [6]. However, the IP multicast distribution scheme using unaltered MMT/IP packets is not standardized, and an experiment for verification on a nationwide-scale had not been done.

III. EXPERIMENT

Our nationwide-scale UHDTV IP multicast distribution verification experiments were conducted from September 29 to November 2, 2018.

We uploaded live 4K UHDTV contents (up to approx. 30Mbps x 2ch) taken in Fukui city and 8K UHDTV content (up to approx. 80Mbps from NHK STRL) by unicast to the distribution server installed in the IX operator in Tokyo. A total of 140Mbps of content was processed by the distribution server using forward error correction (FEC), and was converted to a multicast address and multi-channel distributed to nine CATV operators (in Fukui, Hiroshima, Ehime and Chiba) and communications companies simultaneously. Content distribution to each CATV and communications operator was performed using the existing dedicated line from the IX operator. In addition, it was distributed to the FTTH commercial line owned by the communications company, and IP multicast distribution by MMT was verified. Figure 1 shows the whole system of the large-scale distribution experiments.

To confirm 4K content distribution, the MMT player application developed by NHK was installed on the prototype IP multicast compatible STB, and it was verified at the receiving facility that simulates the FTTH environment of each CATV operator. For 8K content, CATV operators confirmed the reception status using an 8K decoder prototyped by NHK. A packet capture equipment was installed at the output of the distribution server at the IX operator and the MMT packets of the output of the optical network unit (ONU) at the FTTH environment of each CATV management network were recorded, and the jitter of the packets through the distribution line and the packet loss rate were analyzed offline.

The managed networks use CATV distribution lines, which differ general internet lines, and though the guaranteed bandwidth allows high-quality communication, it is still difficult to avoid packet loss. With respect to error correction codes for MMT, six FEC codes are specified in MPEG-H Part 10 [7]. Each FEC has a merit and demerit considering the error...
Correcting capability and the calculation amount. In this experiment, Pro-MPEG FEC [8] was installed, which is relatively light and is resistant to random packet loss. Thus, it allows the recovery of packets lost in processing by the receiver without resending packets at the time of packet loss.

This FEC arranges MMT media packets into a 10x10 matrix. MMT media packets are then calculated by XOR for each row and column to generate FEC packets. If a media packets loss occurs, XOR calculation can be performed on the received media packets, and FEC packets are used to repair the lost packets. Figure 2 shows the packet loss recovery method using an FEC of 10x10. Blocks 1 to 100 indicate MMT media packets, and blocks F1 to F20 indicate FEC packets. Figure 3 shows the results of randomly generated packet loss for 5x5 and 10x10 matrices in the laboratory environment. Using a 5x5 matrix performs slightly better than 10x10, but results in a bandwidth increase of 40%, whereas a 10x10 matrix results in a 20% increase. Therefore, we chose to use a 10x10 FEC matrix because of its relatively small bandwidth increase.

According to the report of Japan Cable Laboratories [9], the bit error rate (BER) of the receiving terminal input signal in the case of the RF transmission method is defined as $1 \times 10^{-11}$ or less. In the case of IP broadcast, the packet error rate (PER) of $1 \times 10^{-7}$ is roughly equivalent to the $1 \times 10^{-11}$ (BER) of the RF transmission method. When PER=$1 \times 10^{-3}$ before FEC processing, PER after the 10x10 FEC processing is $1 \times 10^{-7}$ or less. In October 2018, the Ministry of Internal Affairs and Communications of Japan released a report [10] that defines the technical conditions for IP broadcast, which are listed in Table 1 in terms of packet loss, latency, and jitter. The verification experimental results are provided in comparison with this technical condition in the following section.

<table>
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<tr>
<th>Packet loss rate (After FEC decode)</th>
<th>Latency</th>
<th>Jitter</th>
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<tr>
<td>$1 \times 10^{-7}$ or less</td>
<td>1.0s or less</td>
<td>100ms or less</td>
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IV. RESULT AND CONCLUSION

We confirmed the reception status of the 4K UHDTV content for all CATV operators, which showed that the video image and the audio were not disturbed. We measured over 10 million packets using output from the ONU of the CATV operators to analyze jitter due to transmission. Analysis showed that for 99.9% of the total number of packets, jitter was approximately 30us, which was very small compared to the 100ms observed in the technical conditions. The large-scale IP multicast distribution experiments confirmed that the technical conditions of IP broadcasting for cable television were satisfied. Moreover, simultaneous and multi-channel distribution of 4K/8K UHDTV to nine CATV operators and communications companies was accomplished via the IX operator without using a public CDN. By using IP multicast delivery using MMT, advanced IBB services are expected to be realized.

Considering potential applications, synchronized multi-view contents can be provided by an IBB service using MMT. For example, a sports broadcast program can display an entire stadium on a UHDTV while close-up video of your favorite player is sent to a second screen over a managed network. Furthermore, this technology is expected to be applied to AR (Augmented Reality) and VR (Virtual Reality) technology to provide an experience to viewers as if they were in the stadium.
REFERENCES


