Contribution to the achievement of SDGs by Furukawa Electric Group

Internet Protocol (IP) Broadcasting System for Cable Television (CATV)

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ABSTRACT The Fiber To The Home (FTTH) communication system for CATV, using the Passive Optical Net-work (PON) system, can allow an efficient network. In addition, the IP broadcasting system is provided over managed networks and ensures the same quality as the conventional Radio Frequency (RF) system, thus enabling service provision with minimal picture degradation and delay even when many people simultaneously view real-time broadcasting content. In order to make an IP broadcasting system practical, we will introduce supports for the PON system, methods which enable to objectively evaluate that the system meets the quality specified in the technical standards, and the initiatives to improve the efficiency of the system.

1. INTRODUCTION

CATV was launched with the aim to enable viewing television broadcasts in the areas where it was difficult to view them. By installing cables in the areas to be served and connecting the center stations and subscribers' homes via wired transmission lines, various services, including broadcasting and communication services, are provided.

IP broadcasting is a method of transmitting television broadcasts using IP. With the spread of broadband networks, the transmission capacity required to realize IP broadcasting is being secured. In addition, the technical conditions for the practical application of IP broadcasting have been studied, and the Ministry of Internal Affairs and Communications (MIC) has developed ministerial ordinances[1), 2)]. Since the establishment of technical standards by the ministerial ordinances, the possibility of promoting the introduction of IP broadcasting in the CATV market is expected to be increasing in the future.

2. THE COMMUNICATION SYSTEM FOR CATV

2.1 Overview of FTTH System

CATV transmission systems mainly include Hybrid Fiber-Coaxial (HFC) and FTTH systems, which provide communication services such as television broadcasting services, telephony, and internet. The HFC system is a system that uses both optical fiber and coaxial cables to form a transmission path from a center station to a subscriber's home. The FTTH system uses optical fiber cables for the transmission path from a center station to each subscriber's home. In general, the FTTH system doesn't use active devices that are operated with electricity, and is characterized by excellent maintainability, including that the device failure due to lightning damage is unlikely to occur. Figure 1 shows an example of the FTTH system configuration.

The FTTH systems used for broadcasting services mainly consist of devices such as optical transmitters, optical amplifiers, optical transmission paths, optical splitters, and optical receivers Video-Optical Network Units (V-ONUs). The FTTH systems used for telecommunication services use PON systems. The PON systems are described in Section 2.2. In some cases, broadcasting and telecommunications services are provided using one fiber with optical signals which are wavelength-division-multiplexed, but in most cases, broadcasting and telecommunications services are provided using two separate optical fibers respectively.

2.2 Overview of PON System

The PON system is one of the access network forms used for optical network services for subscribers. An overview of the PON system is shown in Figure 2. In a transmission path, optical signals are split into multiple branches using an optical splitter, which is a passive component. An Optical Line Terminal (OLT) is installed at the center station, converts optical signals and electrical signals, and processes communication signals for subscribers and upper hierarchy networks. An Optical Network Unit (ONU) is installed at each subscriber's home, converts optical/electrical signals and transmits/receives communication signals from the subscriber's home to the OLT. The PON system is becoming increasingly popular because it can realize an efficient network by connecting multiple ONUs to one OLT, thereby sharing part of the optical transmission path.

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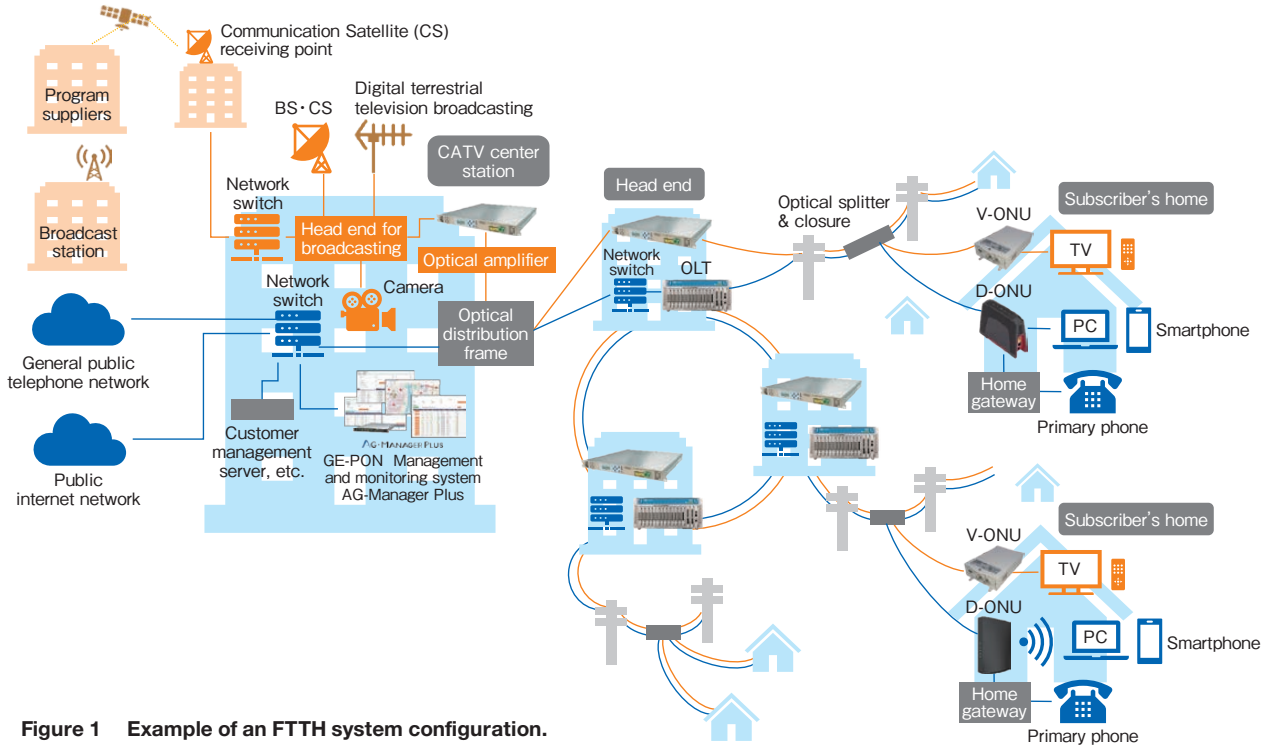

Figure 1 Example of an FTTH system configuration.

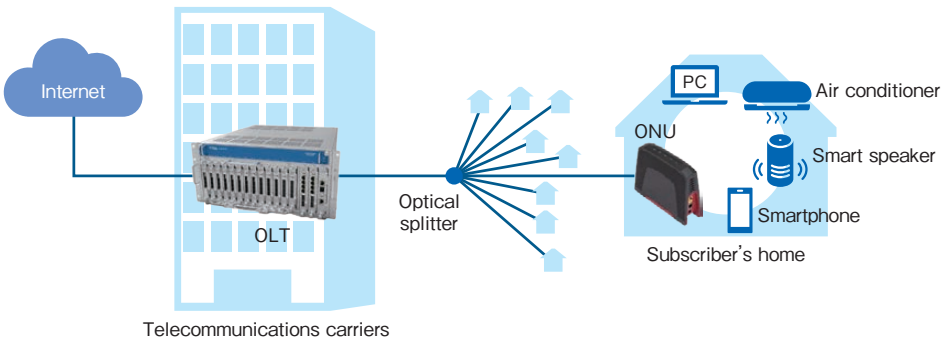

Figure 2 Overview of a PON system.

3. EXAMPLE OF IP BROADCASTING SYSTEM CONFIGURATION

Figure 3 shows an example of a possible configuration for an IP broadcasting system. For digital terrestrial television broadcasting, Broadcasting Satellite (BS) digital, and advanced BS digital broadcasts, signals are received at the head end of a CATV operator's center station, demodulated by an RF broadcast receiver, converted to an IP stream, and input to an IP broadcast transmitter (in this case, IP broadcast server[3]). For multi-channel independent broadcasting, signals provided by the platform operator are also input to the IP broadcast transmitter. The IP broadcast transmitter transmits signals to the access network managed for the subscriber's home in a multicast format as signals for IP broadcasting service. The transmitted IP broadcast signal is transmitted through the PON system and is viewed at the subscriber's home via an IP-Set Top Box (IP-STB).

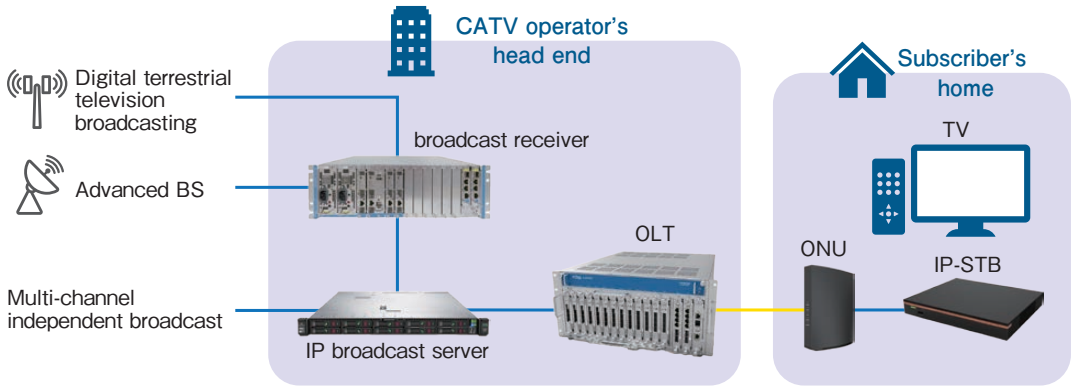

Figure 3 Example of IP broadcasting system configuration.

4. REQUIREMENTS FOR IP BROADCASTING

4.1 Multicast Communication Method

Most IP communication services use the unicast method. The Unicast is a standard method of one-to-one communication with a single peer, and the Transmission Control Protocol (TCP) is used for video distribution services such as Over The Top (OTT). Since TCP establishes a connection by handshaking before communication, confirms the reception of the peer, and performs retransmission processing, it is not suitable for IP broadcasting systems which require real-time transmission to multiple parties.

IP broadcasting uses the multicast method. The multicast is a method of one-to-many communication by specifying specific addresses and the User Datagram Protocol (UDP) is used. Since UDP does not establish a connection before transferring data or confirm the status, it has less delay and is a suitable protocol for applications that require real-time performance. In the case of unicast, if the same program is viewed at multiple subscribers' homes, bandwidth for the number of subscribers viewing programs is required at the upper stream. On the other hand, in the case of multicast, even when the same program is viewed, the bandwidth required at the upper stream is only for the number of programs. When many subscribers watch the same program at the same time, multicast is more bandwidth efficient. Figure 4 shows the bandwidth required for unicast and multicast.

For the multicast system, there is a function called Internet Group Management Protocol (IGMP)/Multicast Listener Discovery (MLD) snooping. Using this function, only broadcast signals that have been requested for viewing under a device such as a switch can be distributed to the path under that device. Since broadcast signals that are not being viewed are not passed downstream (to the subscriber's network), bandwidth usage is more efficient.

4.2 Quality of IP Broadcasting

Video distribution services using unicast have been increasing in recent years, and with this increase, the means of viewing real-time broadcast contents (transmission timing is determined by the service provider) via the Internet has been also diversified. A variety of contents can be viewed if a communication environment is available, however, when many people access the service at the same time, quality issues such as delays due to congestion or degradation or freeze of picture quality may occur.

In contrast, IP broadcasting is provided over a managed network and ensures the same quality as conventional RF systems, therefore service provision with minimal picture quality degradation and delay become possible.

The quality to be meet in IP broadcasting is specified in the 'Ministerial Ordinance Specifying Technical Standards for General Cable Broadcasting Quality'[1], and it said that "IP addresses to be used for IP broadcasting shall be notified separately by the Minister of Internal Affairs and Communications" and "shall be used for 'multicast addresses' after that public notice"[2]. In addition, this Ministry's Ordinance defines packet loss, average delay time, fluctuation of average delay time, … etc. for the quality, therefore, it is necessary to build a system that conforms to these technical standards for providing IP broadcasting services.

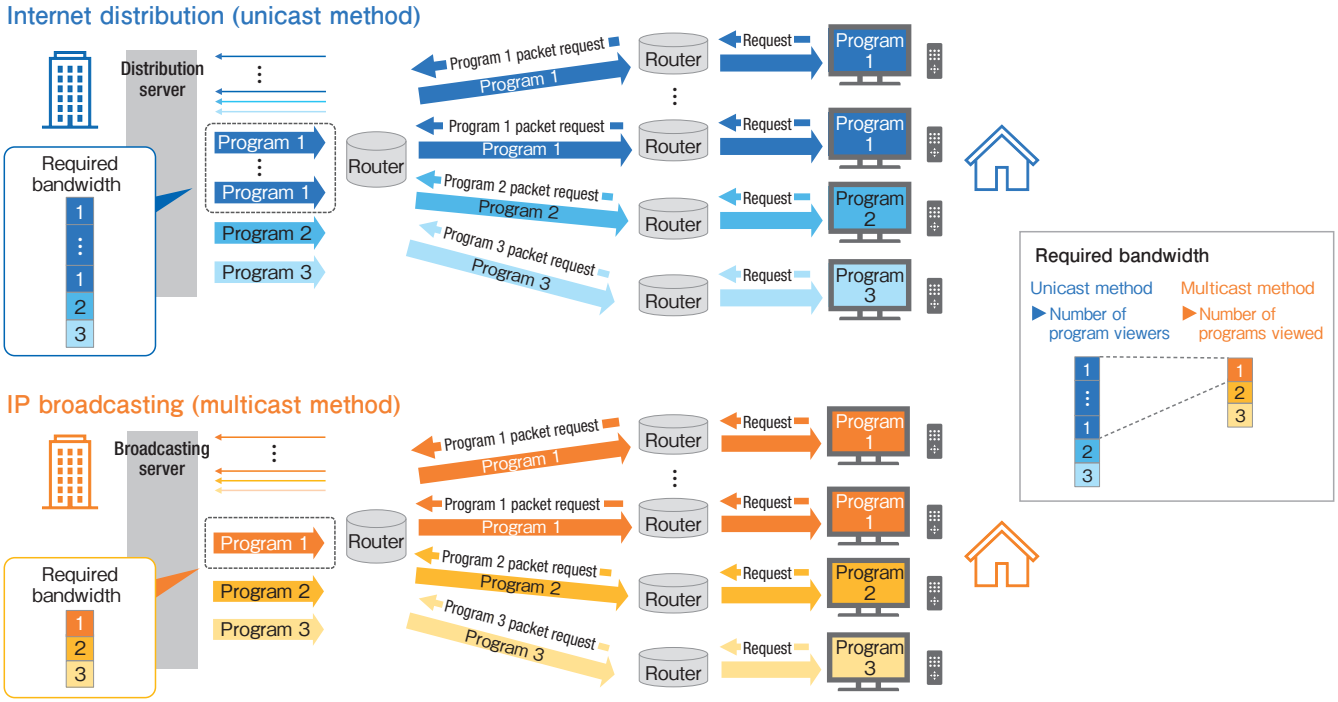

Figure 4 Unicast and Multicast.

5. ISSUES AND INITIATIVES TO REALIZE IP BROADCASTING

5.1 PON System Support for IP Broadcasting

IP broadcasting systems are required to use multicast addresses, and also systems including transmission paths must support multicast. For example, broadband routers placed in homes may be commercially available products, but there are a wide variety of products on the market, and it may be difficult to support multicast and ensure the quality of wireless Local Area Network (LAN). Our ONU with built-in broadband router meets the requirements for IP broadcasting and is easier to manage. The specifications of our ONU AG30 with built-in broadband router are shown in Table 1 and its picture is shown in Figure 5.

If subscribers freely select broadband routers, they may not be able to manage requirements to guarantee service, such as support for firmware updates, and specifications regarding multicast, for example, may be changed without notice. As a result, the quality of broadcasting service cannot be guaranteed, and there is a possibility that stable video transmission may not be possible.

Since our ONU AG30 with built-in broadband router provides a router section as an integrated unit, it enables the stable provision of broadcasting services. In addition, the PON management and monitoring system enables management and monitoring, such as mode setting and setting information acquiring of the AG30 router section from the center side. A mesh client for the broadband router is also provided, therefore the wireless LAN coverage area can be extended as needed.

5.2 Conformance Evaluation to Technical Standards

As mentioned above, IP broadcasting has technical standards as a network that are different from those of RF systems, therefore it is necessary to have a method that can objectively evaluate whether the built system meets the quality specified in the technical standards.

In this initiative, we present a method to confirm that broadcasting services can be provided with quality in accordance with the technical standards of the ministerial ordinance by using an IP broadcast quality monitoring server to evaluate items specified in the technical standards, such as packet loss rate, average delay time, and fluctuation of average delay time in the system.

Table 1 Specifications of ONU AG30 with built-in broadband router.

Item	Specifications
Transmission medium	1.3 μm zero-dispersion optical fiber
Optical wavelength	Downstream: 1575 to 1580 nm (10G) Upstream: 1260 to 1280 nm (10G), 1300 to 1320 nm (1G)
Allowable optical transmission loss	29.0 dB (including power penalty of 1.0dB)
Structure	Main body (Router, ONU), AC adapter
PON port (SC/SPC)	Downstream: 10 Gbps continuous, Upstream: 1 Gbps burst (10G non-supported) Downstream: 10 Gbps continuous, Upstream: 1 Gbps burst (10G supported) * SFP+type 10G- EPON ONU Transceiver
LAN	LAN1: 10GBASE-T/5GBASE-T/2.5GBASE-T/1000BASE-T/100BASE-TX LAN2, LAN3: 1000BASE-T/100BASE-TX/10BASE-T
	Auto-Negotiation/Fixed (Full duplex/Half duplex)
	Auto MDI/MDIX
TA	1000BASE-T/100BASE-TX/10BASE-T
	Auto-Negotiation/Fixed (Full duplex/Half duplex)
	Auto MDI/MDIX
Power supply /Power consumption	AC100 V / 28 W or less
Dimensions	78.8 (W) x 185 (D) x 240 (H) mm
Mass	Main body: 0.8 kg or less / AC adapter: 0.2 kg or less
Wireless LAN Standards	IEEE802.11b/11g/11a/11n/11ac/11ax
Antenna	2.4 GHz/5 GHz communal (built-in): Transmitting 4 × Receiving 4
Beam-forming	Supported
Channels	2.4 GHz: 1 to 13ch 5 GHz (W52, W53, W56): 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112,116, 120, 124, 128, 132, 136, 140, 144ch
Wireless security	WEP (64bit), WEP (128bit), WPA/WPA2- PSK (TKIP/ AES), WPA2-PSK (AES), WPA2/WPA3-PSK (AES)
MU-MIMO	Supported
Multi SSID	2.4 GHz x 1, 5 GHz x 1, Guest SSID x 1
Setup method	WPS supported
Mesh client	Proprietary function
Others	UPnP supported, IPv6 pass-through supported, Access control supported, VPN pass-through supported, DMZ supported

Figure 5 Picture of ONU AG30 with built-in broadband router.

Figure 6 shows an example of the quality measurement configuration, and Table 2 shows examples of items that can be evaluated and their values specified in the technical standards. This quality measurement can be used to check whether the quality of the network section from the head end to the subscriber's home meets the specifications.

Monitoring signals transmitted from the IP broadcast server in real time, it is also possible to support operations with functions such as log display of detected information, stored recording of each signal, and reproduced transmission.

5.3 System Efficiency

In order to cover the entire FTTH service area, CATV operators may have multiple sub-center stations in addition to the center station, and may provide different broadcasting services for each station.

In such cases, we are examining a system in which an IP broadcast server and an IP broadcast relay server are installed as needed and broadcast services can be transmitted efficiently. It is possible that the signals of the master head end in the center station is flexibly treated, as needed, either shared with the sub head ends in the subcenter of added sub head ends' own broadcasting services to it. An example configuration using an IP broadcast relay server is shown in Figure 7.

In addition, during the transition period to IP broadcasting, it is expected that the system will be used in combi-

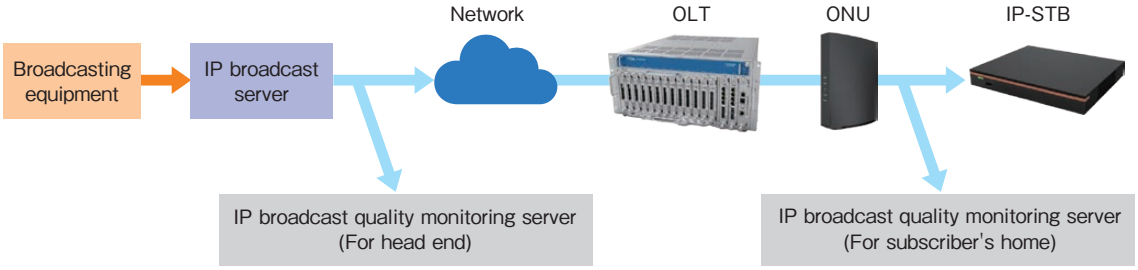

Figure 6 Example of quality measurement configuration.

Table 2 Evaluation items and provisions.

Evaluation Items	Provisions of the Ministerial Ordinance	Specified Value
Packet loss ratio	Article 23, Overall Quality	1 x 10^{-7} or less
Average delay time	Article 24, Network Quality	1 second or less
Fluctuation of average delay time		100 milliseconds or less

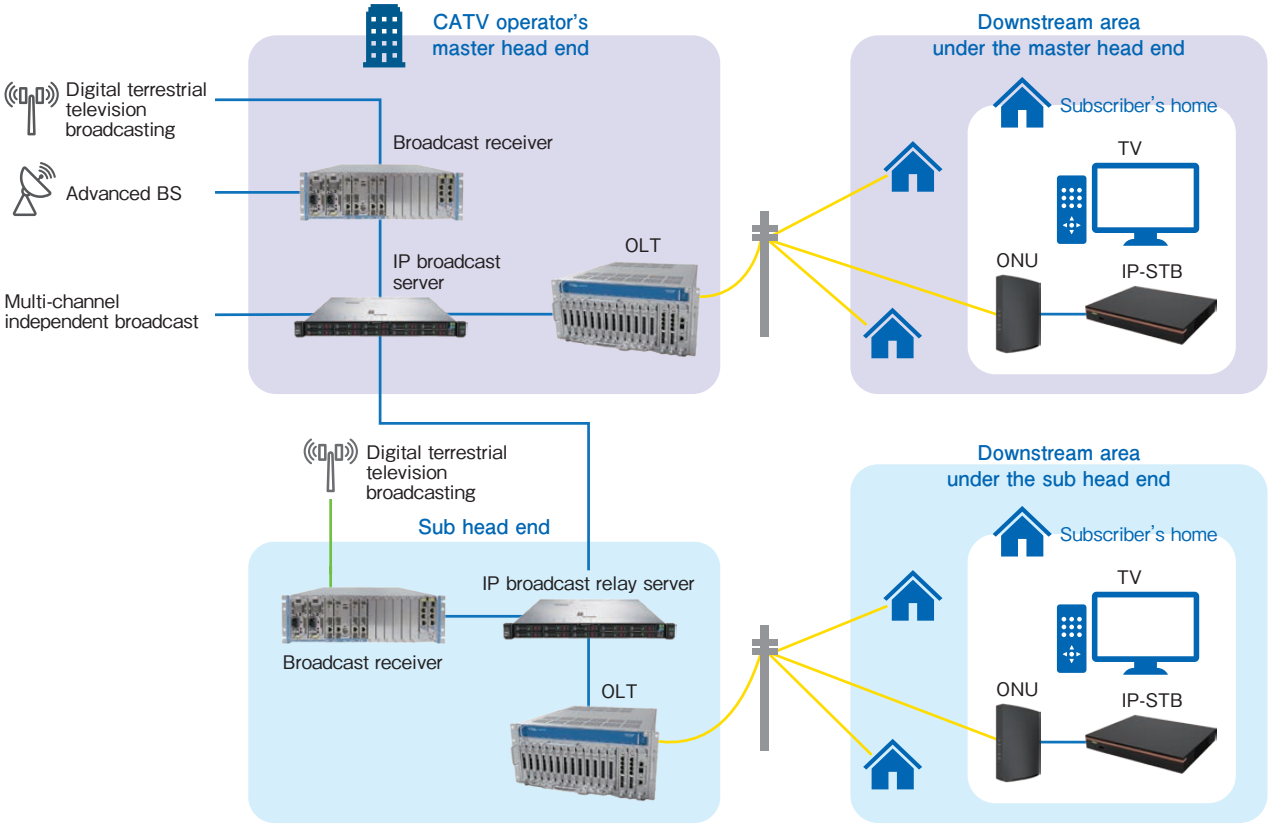

Figure 7 Configuration example using IP broadcast relay server.

nation with existing RF systems, so slimming down of the installed facilities and power saving are required. We are developing an IP broadcasting system that includes an RF signal receiver and IP broadcasting transmitter in a compact configuration. Moreover, when IP broadcasting services are provided, sharing the PON system by both the communication service and the broadcasting service enables the efficiency improvement of the system including the transmission path.

6. CONCLUSION

The FTTH communication system for CATV, using the PON system, can allow an efficient network. In addition, the IP broadcasting system is provided over managed networks and ensures the same quality as the conventional RF system, thus enabling service provision with minimal picture degradation and delay even when many people simultaneously view real-time broadcasting contents.

In this initiative, we introduced the PON system support and the methods which enable to objectively evaluate the system that meets the quality specified in the technical standards. In addition, solutions for improving system efficiency were presented to address issues for actual implementation, such as methods for sharing broadcast content among locations and using the system with existing RF systems.

By shifting to IP broadcasting, most of the FTTH broadcasting system can be configured with general-purpose communication devices, and in the future, optical fibers used for RF broadcasting can be diverted to other applications as well.

We intend to continue our efforts to add new value to the CATV infrastructure, which reserves such potential.

REFERENCES

1) Ministry of Internal Affairs and Communications: “Ministerial Ordinance Establishing Technical Standards for Cable General Broadcasting Quality”.
https://www.soumu.go.jp/main_content/000579341.pdf
(Referred on Jan.15, 2025) (in Japanese)
2) Study Group on Cable Television Video Distribution in the 4K and 8K Era: “Draft Report, June 2018”.
https://www.soumu.go.jp/main_content/000558750.pdf
(Referred on Jan.15, 2025) (in Japanese)
3) Hideki Yamamoto, Yoshihiro Ueda, Kazuhiro Watanabe: “IP Video Delivery over CATV for Advanced Broadcasting Service”, OKI Technical Review, No. 227, Vol.83, (May 2016).
https://www.oki.com/jp/otr/2016/n227/pdf/otr227_r13.pdf
(Referred on Jan.15, 2025) (in Japanese)