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A Study on the IP Transmission Stream for High-Definition Image Transmission

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Abstract

In order to broadcast 8K UHD, domestic broadcasting is upgrading production, operation, and transmission technologies in a new way that has various forms such as terrestrial broadcasting, IPTV, mobile, and streaming services. In order to overcome the existing SDI transmission technology that has reached its limit, new transmission technologies using ICT-based convergence such as IT, Network, IOT, and Big Data are developing. Internet Protocol(IP) transmission technology is an IT-based core protocol that transcends various broadcasting infrastructures. Therefore, it can be said that the technology for converting the broadcasting system based on IP is a natural one for preparing for 8K UHD in the future. In this paper, we propose an IP transmission system that adopts a network that can transmit 8K with hardware of 12G Serial Digital Interface (SDI), in order to prepare for the future broadcasting system according to the development of ALL IP interface technology.

Keywords: *Internet Protocol, 12G-SDI, ATSC3.0, 4K UHD, 8K UHD*

1. Introduction

The transition from analog broadcasting to digital broadcasting is coming to an end [1]. UHD, which is provided in Korea, transmits video and audio data with a resolution of 3840×2160(4K) through the terrestrial broadcasting network; and as a service that provides content with improved quality compared to the existing FHD, the main broadcasting started in 2017 mainly in large cities in Korea [2]. However, since there has been an increasing demand for 8K-UHD high-quality media, based on ATSC 3.0 broadcasting networks and network convergence transmission, technologies related to video streaming and file updown converting products are being developed, for 8K-UHD broadcasting service. As such UHD production technology is changing, preparations are also underway in order to provide 8K-UHD services in terrestrial broadcasting. However, if we use only terrestrial broadcasting networks, the transmission bandwidth of the production system to provide 8K-UHD service is not enough. Therefore, in order to transmit high-quality and large-capacity video files, research on convergence network transmission technology, utilizing next generation

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communication networks and terrestrial broadcasting networks, is in an essential situation.

Since the ATSC 3.0 requires IP-based transmission technology to make it easier to integrate broadcasting services with Internet-based technologies, in this paper we define the system necessary for future 8K UHD operation and derive the research direction through the technical comparison of this part.

2. Standardization and Technology Trends for the Advanced Television Systems Committee 3.0

Compared to the previous standard ATSCA/53, the Advanced Television Systems Committee 3.0 (ATSC) has been improved significantly for a terrestrial digital broadcasting standard. The structure of ATSC 3.0 has been improved to enable network manufacturers to operate efficiently with flexibility and stability [3]. If we use the latest encoding and modulation techniques, we can effectively utilize the limited spectrum resources. By exploiting minimal resources with generated capacity, we are able to transmit 4K and 8K UHD video contents and high-capacity realistic content to end users. Due to the ever-evolving IP technology based on Baseband, we have been able to efficiently combine terrestrial broadcasting with other IP-based services. The current ATSC 3.0, which uses terrestrial standards, adopts High Efficiency Video Coding (HEVC) as a technology for compressing video data and MPEG-H as a technology for compressing audio data. Using this technology, the ATSC 3.0 technology standard can transmit 25Mbps of data with a capacity of 30% or more than ATSC 1.0 [4]. The table 1 shows the gigabytes and formats required by SDI standards. It can be seen that movement of UHD 60-fps content requires a 12G-SDI connection.

Table 1. SDR recommendation standard

Standard	Capacity	Bir Rate(Gbps)	Format
SMPTE ST 292	HD-SDI	1.485	720p
SMPTE ST 424	3G-SDI	2.970	1080p
SMPTE ST 2081	6G-SDI	6	2160p 30 fps
SMPTE ST 2082	12G-SDI	12	2160p 60 fps
SMPTE ST 2083	24G-SDI	24	2160p 120 fps

By designing physical layer specifications based on Orthogonal Frequency Division Multiplexing (OFDM), we also consider improving the performance of multipath channels and the broadcasting, based on ATSC 3.0 Single-Frequency Network (SFN). The previous ATSC 1.0 supported only a single transmission rate, but current ATSC 3.0 supports broadband transmission rates in order to provide comprehensive services such as video/audio technologies with various qualities. ATSC 3.0 can realize the crossover, using Layered Division Multiplexing (LDM), the latest multiplexing technology that can efficiently transmit fixed UHD broadcasting and mobile HD broadcasting at the same time, and since the system is completely designed with IP-based, ATSC 3.0 can provide high-quality media to various terminals by enabling interworking with communication networks. Due to these features, UHD broadcasting will play a significant role in strengthening content competitiveness in the diversified media market such as personalized terminals and devices.

3. 12G Serial Digital Interface(SDI) and Internet Protocol(IP) SYSTEM

3.1 12G-SDI

The 12G-SDI, with the new transmission standard 4K·2160p, can transmit 8 times the HD-SDI (2K·1080i) and 4 times the 3G-SDI (2K·1080p), and the electrical and physical characteristics were standardized in SMPTE ST 2082-1 in 2015. The main feature is that 4K 4:2:2 50P/60P can be transmitted using a single cable, and as shown in the figure 1, the four 3G SDIs can be processed by multiplexing with a single-core processing port of 12G-SDI 10-Bit.

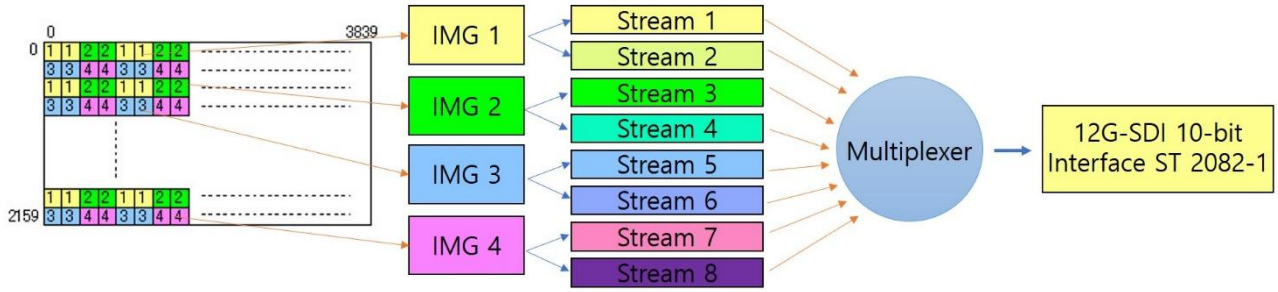

Figure 1. 12G-SDI multiplexing process

3.2 Internet Protocol(IP)

As a standard for UHD broadcasting of next-generation terrestrial broadcasters, ATSC 3.0, is a standard that defines classes, from application class to physical class [5]. Standard ATSC 3.0, as an IP-based UHD broadcasting system, is a protocol that enables transmission of data by using the Internet network and the broadcasting network at the same time. In the broadcasting system, UDP/IP-based ROUTE (Real-Time Object Delivery over Unidirectional Transport) protocol or MPEG Media Transport (MMT) protocol are used; and in the Internet network system HTTP, TCP, and IP protocols are used [6]. Also, for the interface between the IP layer and the ATSC 3.0 physical layer, ALP (ATSC 3.0 Link-Layer Protocol) is used. Table 2[7] shows ATSC 3.0 Protocol stack at a glance.

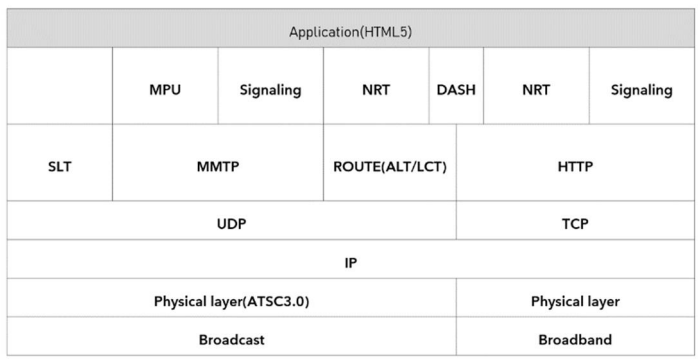

Figure 2. ATSC 3.0 protocol stack

3.3 Functional Comparison of 12G SDI and IP

In order to transmit UHD image signal the SDI method of HD system, used in broadcasting, uses three methods (12G-SDI, Dual 6G-SDI, and Quad 3G-SDI) as standard [8]. Since the Dual, Quad, and SDI methods require two or four times the number of cables to build a UHD system, compared to the existing HD method, there arises technical constraints for building the system. By using the same single-core cable as the previous

method, 12G-SDI has the advantage of being able to transmit UHD, but it is difficult to construct s stable system of 12G-SDI, because attenuation of signal quality occurs greatly at a distance of 50M or more.

In particular, 12G-SDI has a fatal weakness that 8K UHD transmission, which will be introduced in the future, is not possible [9]. Table 2 shows the difference between SDI and IP.

Table 2. Functional comparison of SDI and IP

IP	SDI
Maximum competency/priority	Guaranteed bandwidth
Probability theory	Determinism
Dynamic/Routing	Connecting a Fixed Circuit
Multiple signals	Single signal
Asynchronous timing	Synchronous timing
Non-real time/jitter reorder	Realtime
Variable latency/Utilization	Low latency
Packet loss/retransmission/FEC	Normal Operation
Independently	One after the other

3.4 Conversion to IP

The UHD (4K/60p) images, currently being transmitted, require 12Gbps of transmission bandwidth for uncompressed transmission, and 144Gbps bandwidth is required in order to implement 8K/120p UHD in the future [10]. The ST2110-20 transmission standard is a technology that tries to apply IP-based transmission technology to broadcasting, by completing network specifications with above 100Gbps. If we convert the protocol to IP by this transmission standard, we can transmit image data using the existing optical network environment; and if we use 10Gbit/s Network Card, we can support higher bandwidth compared to SDI I/O Board, and reduce the quantity and cost of SDI cables needed to connect the system. Furthermore, the size of the systems we need is reduced, which also increases spatial efficiency, and has the effect of saving the cost of adding and changing broadcasting systems. Next, even if the specification and format of the images are changed in the future, it also has the advantage of being able to maintain the interface as it is. IP can be considered as an alternative to consider a limited equipment demand, a protocol conversion, a cabling, and a space-saving; while at the same time to have a flexible, easy-to-use and economically sustainable UHD (4K/8K) ecosystem.

5. Conclusion

IP transmission technology is an IT-based core protocol that transcends various broadcasting infrastructures such as data transmission of 8K resolution, Internet 4K streaming, and realistic media; the transport layer in the IP infrastructure environment has improved routing technology and ultra-wideband bit rate, compared to the baseband transmission technology based on the 12G serial digital interface (SD) of the current broadcasting system. The ultra-wideband 8K UHD broadcasting environment, which will be formed in the coming future, is an optimal alternative to improve the transmission technology of system workflow. The system also has the advantage of being able to flexibly operate a multidisciplinary model room to control studios, depending on the nature of broadcasting and a workflow for remote production, such as simultaneous multidisciplinary

broadcasting. In the future, broadcasting media technology will develop in various forms by having high quality technology based on large capacity broadband. In particular, uncompressed data for large-capacity transmission technology can be said to be an essential alternative technology for broadcasters preparing for an 8K UHD broadcasting system. The technology that can be used in preparation for such a change is the IP transmission technology.

In this paper, we have presented and explained the convergence transmission systems of broadcasting and communication and service technologies, in order to exploit these IP transmission technologies. In the future, in 8K UHD broadcasting to which ATSC 3.0 technology is applied, academic demonstrations based on the research and development of products should be additionally carried out so that the systems and equipments can be compatible.

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