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Design and Realization of Multiplexing System for Fixed/Mobile Next-Generation Broadcasting Service in Network Free Environment

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ABSTRACT

The Current broadcasting enviroment is constally evolving in order to meet the various needs of the viewer such as Color TV, 3D, HD, UHD TV serivce. And they want to broadcast the same quality in the fixed and mobile enviroment for high definition braodcasting serive. In this paper, we presnet a design and implementation of muilplexing system for fixed/mobile next generation broadcasting service in network free enivorment. Network free means receive both the broadcasting channel and communication chennel for various TV service. We introduce method to provide next generation convergence broadcating servies based on european standard which can transmit UHD content in network free envieroment. As a result to this paper, we analyze the characteristics of the recieved signal from the commerical receiver device.

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1. INTRODUCTION

As the global analog to digital broadcasting transition is nearing completion, research on next-generation broadcasting standards is taking place in preparation of the upcoming UHD realistic, high-capacity broadcasting and communication convergence era that surpasses current HD. Viewers have embraced and consumed diverse multimedia formats with the changes in time and the development of technology, and now they are demanding higher quality services. Gradually, these requirements have brought technological advancements in the respective areas. Viewer demands in the broadcasting domain have evolved black and white TV into color TV. As the sense of presence and reality of color TV is increased, High Definition (HD) TV and 3D TV have emerged. Recently, Ultra HD (UHD) TV has been introduced, providing 4 times bigger image than HD, as well as, more clear, higher resolution images.

HD, 3D, and UHD services are provided for fixed broadcast viewing. Low quality services are provided for mobile broadcasting. Nowadays, viewers are demanding the high-quality services of fixed broadcasting in the mobile environment as well.

However, the currently established Advanced Television System Committee (ATSC) systems can not meet these requirements.

Therefore, in this paper, research on mutiplexing technology of next-generation European broadcasting is performed. The next-generation European broadcasting can serve as a basis to provide

fixed/mobile converged broadcasting services that can satisfy the heightened viewer expectations. Based on the results a software multiplexer structure is proposed.

The paper is organized as follows. In section 2, the characteristics of the next-generation European broadcasting system are considered in order to determine how it can be used to transmit next-generation broadcasting contents. In section 3, the design and implementation of the multiplexer structure that can support fixed/mobile converged services based on the next-generation European broadcasting system is presented. Section 4 provides concluding remarks.

2. ANALYSIS OF NEXT GENERATION BROADCASTING

2.1. Overview of Nertwork Free Environment

Analog-to-digital transition of broadcasting system is being carried around the globe. In Korea, the digital transition was completed in December 2012. Terrestrial broadcasting in Korea uses ATSC 8-VSB system in 6MHz bandwidth to service stationary terrestrial HD broadcasting. Mobile broadcasting in Korea uses DMB broadcasting system which is based on the European DAB. It services QVGA mobile broadcasting. However, it is difficult to satisfy the elevated needs of the viewers with the aforementioned systems. Viewers today are demanding high-quality video surpassing HD, as well as, realistic, immersive media broadcasting experience. In addition, they are demanding high-quality broadcasting services in mobile environment. In order to meet these demands, the “Network Free” project is being carried out in Korea.

The goal of the project is provide mobile HD-class high-quality broadcasting service and fixed UHD convergence broadcasting service in a broadcasting and communication converged, network-free environment. The diagram of network free environment is as shown in Figure 1. SHVC video compression technology is used to compress the 8K UHD video, to obtain 8K UHD additional data, 4K UHD additional data, and HD video data. The multiplexing system proposed in this paper is used to transmit the 4K additional data and HD video through the terrestrial broadcasting network. The stationary receiver can receive 4K additional data and HD video to play 4K UHD video. The mobile receiver is able to receive HD video and play it. The receiver that can process 8K UHD video can use the communication network to request and obtain 8K additional data and use it to play the 8K UHD video.

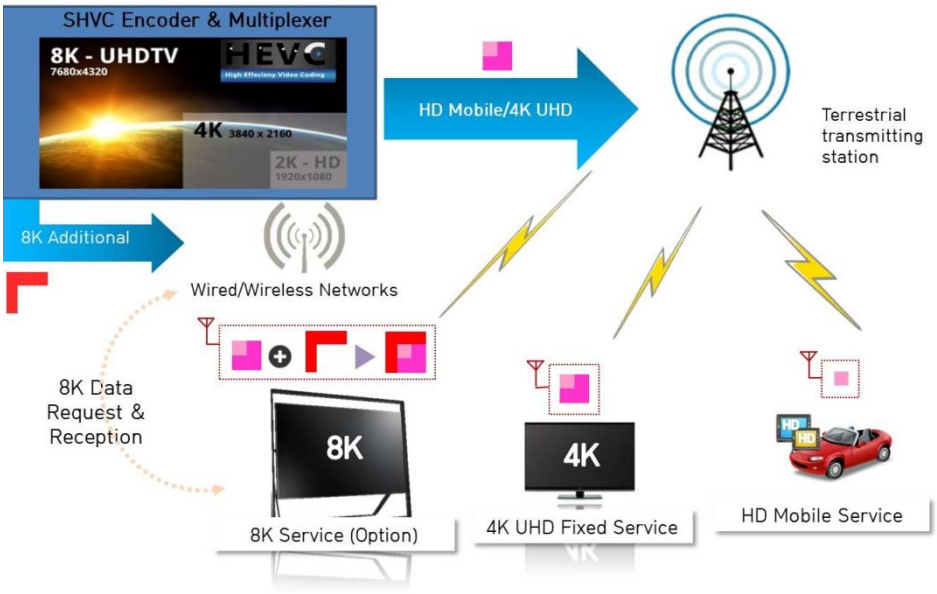

Figure 1. Conceptual diagram of Network Free Environment

This paper presents the results of the first step of the research project. The next-generation European terrestrial broadcasting technology, which is capable of 4K contents transmission, is analyzed. Based on this, a software based multiplexer architecture is proposed.

2.2. Analysis of DVB-T2 System

The European broadcasting standard has been released according to the transmission media as terrestrial, satellite, and cable. It has been adapted as broadcasting standard in various regions throughout the world and actual commercial broadcasting is taking place [1]. Currently, there are first generation digital broadcasting systems developed for analog to digital transition of broadcasting. It has been 10 years since their establishment, and second generation has been developed due to the demand of service providers to improve transmission efficiency and to enable flexible use of the transmission network [2]-[4].

Table 1. Specifiaction of each generation of European terrestrial broadcasting

	DVB-T	DVB-T2
Input interface	Single TS	Multiple TS and GSE
Modes	Constant Coding & Modulation	Variable Coding & Modulation
FEC	Convolution Coding + RS	LDPC + BCH
	1/2, 2/3, 3/4, 5/6, 7/8	1/2, 3/5, 2/3, 3/4, 4/5, 5/6
Modulation	OFDM	OFDM
Modulation Schemes	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, 256QAM
Guard Interval	1/4, 1/8, 1/16, 1/32	1/4, 19/256, 1/8, 19/128, 1/16, 1/32, 1/128
FFT Size	2K, 8K	1K, 2K, 4K, 8K, 16K, 32K

The next-generation broadcasting standard T2 is a terrestrial broadcasting method that uses OFDM modulation method as a basis. Error correction has been improved through the use of LDPC & BCH coding and bit/cell/time frequency interleaving. Data transmission rate is improved by incorporating 256QAM. In addition, overhead has been reduced by using varying sizes of FFT, guard intervals, and efficient pilot patterns. Its overall performance is improved compared with the first generation digital broadcasting system by using constellation rotatin, PAPR reduction methods, MISO methods, etc.

2.3. Analysis of DVB-T2 Standard for UHD Service

In this section, an analysis on the possibility of data transmission of next-generation European broadcasting is performed for providing high-quality converged broadcasting services through fixed/mobile converged broadcasting. The next-generation image compression standard HEVC has 35% coding efficiency compared with H.264/AVC, and it is a core technology that can efficiently compress the enormous data generated by HD and UHD images. When compressing a 4K UHD image using HEVC standard, approximately 25 Mbps of capacity is required [5], [6].

A Transmission rate depending on transmission parameters is shown in Table 2. The corresponding analysis result is part of the project research. Before transmitting 8K UHD contents through heterogeneous networks, transmission performance is verified for transmission of 4K UHD and HD convergence broadcasting using terrestrial single channel, and derived the following performance through simulation experiment. In the simulation experiment, the latest transmission methods, channel coding methods, and video compression methods are used. When obtaining 4K UHD additional video information (Fixed) and HD base video information (Mobile) using SHVC video compression technology, 28 to 30 Mbps of data transmission rate is required [7]. The performance indicators define the maximum transmission rate that the multiplexing system can handle.

For the next-generation European terrestrial broadcasting standard DVB-T2, the optimal transmission parameters for 4K UHD broadcasting service for fixed/mobile converged broadcasting through single terrestrial channel can be verified under the conditions specified below.

Table 2. Transmission rate depending on transmission parameters (Bandwidth : 6MHz)

Transmission Rate (Mbps)	Fixed Trans Rate	Mobile Trans Rate	Fixed code rate	Mobile code rate	FFT Size	CP Size	Pilot Mode
29.03	21.77	7.26	4/5	4/5	8192	1/32	PP4
29.34	22.00	7.33	4/5	4/5	16384	1/32	PP4
29.36	22.02	7.34	4/5	4/5	32768	1/32	PP4
29.34	21.77	7.57	4/5	5/6	8192	1/32	PP4
29.65	22.00	7.65	4/5	5/6	16384	1/32	PP4
29.67	22.02	7.65	4/5	5/6	32768	1/32	PP4
29.95	22.70	7.26	5/6	4/5	8192	1/32	PP4
30.27	22.94	7.33	5/6	4/5	16384	1/32	PP4
30.29	22.95	7.34	5/6	4/5	32768	1/32	PP4
29.64	22.23	7.41	5/6	5/6	4096	1/32	PP4
30.26	22.70	7.57	5/6	5/6	8192	1/32	PP4
29.25	21.94	7.31	5/6	5/6	8192	1/32	PP4

3. DESIGN AND IMPLEMENTATION MULTIPLEXING SYSTEM

3.1. Architecture of Proposed Multiplexing System

The structure of the proposed multiplexer that supports converged services is shown in Figure 2. One or multiple input can be received through the multiplexer to transmit a single legacy broadcasting or to transmit multiple broadcasting contents that support fixed or mobile converged services transmission of UHD contents by applying the data transmission rate analysis described in section 2.

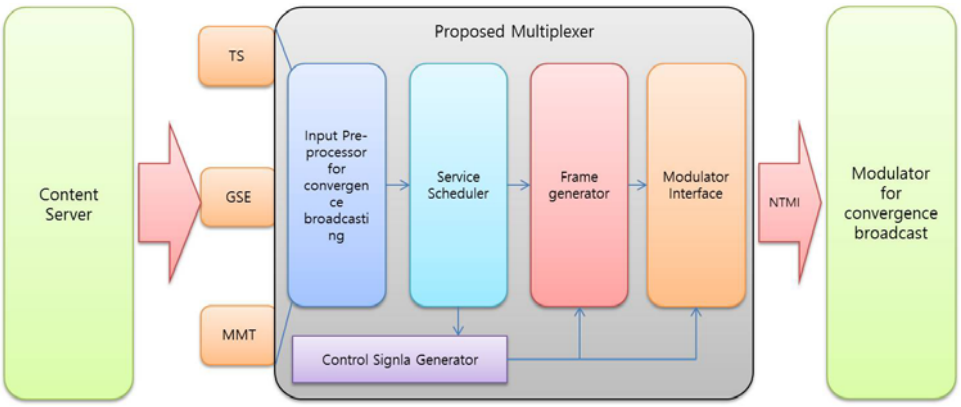

Figure 2. Diagram of multiplexer that supports converged services

3.2. Design and Implementation of Multiplexing System

The input handled by the proposed multiplexing system includes the TS, which is used in most broadcasting systems today, Generic Stream Encapsulation (GSE), and MPEG Media Transport (MMT). TS has been used as the technical standard for multimedia transmission in broadcasting systems for a long time, and it has been chosen for backwards compatibility with legacy broadcasting. GSE is the input method chosen by the next-generation European broadcasting system that enables efficient processing of the increasing diverse forms of multimedia services in the Internet. MMT is an IP friendly transmission method that can provide IP based broadcasting in terrestrial, satellite, and cable broadcasting networks. It can use different types of networks simultaneously to transmit multimedia. By adapting the above input methods, the proposed multiplexer can maintain compatibility with the existing broadcasting networks and provide a structure for IP based services for next-generation broadcasting.

The multiplexer proposed consists of an input pre-processor module, a service scheduler and frame generation module, a control information generation module, and modulator interface module. The input pre-processor organizes the input that has various forms into a logical structure that the multiplexer can process. The service scheduler and frame generation module creates a frame structure that can handle converged services. The control information generation module creates information on the contents transmitted and frame structure information generated. The modulator interface module transmits the frame generated by the multiplexer to the next-generation converged broadcasting modulator.

The input pre-processor of the multiplexer receives 4K UHD contents from a GSE, MMT based on TS or IP and processes by applying Network Free Pipe (NFP) multiplexing method that mixes data from different layers into a single transmission frame and transmits through a single frequency band.

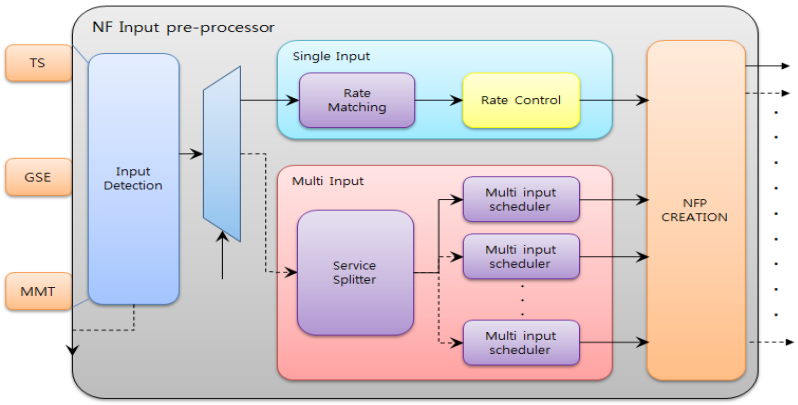

Figure 3. Input pre-processor for the proposed multiplexing system

The support scheduler provides structure information of the logical frame generated by the input pre-processor to the control and signaling information generator. It also handles the delay caused due to multiple service support frames. The control and signaling information generator module, which is based on the next-generation European broadcasting standard, adds system parameter and configuration information to the frame depending on the overall frame structure information and transmission parameter settings. The European broadcasting standard generates control information based on specific parameters for each transmission media. The converged service supporting multiplexer adapts those respective parameters and additional parameters for mobile service support has been designed. The baseband frame generator module creates the converged service supporting transmission frame based on the control information and contents.

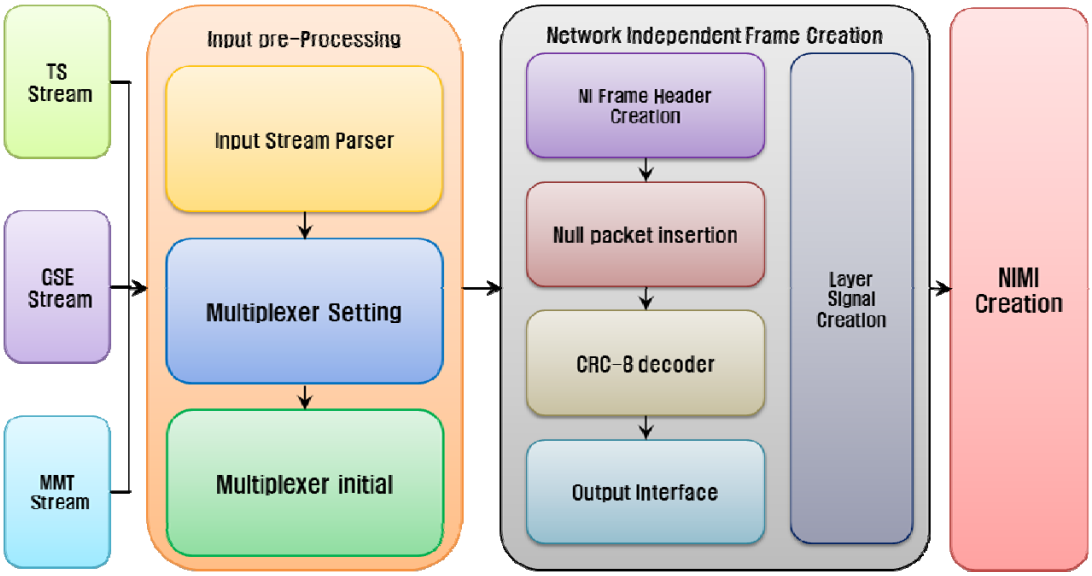

Figure 4. Operation structure of the proposed multiplexing system

The frame information generated for the multiplexing system is transmitted using the next-generation converged broadcasting modulation system. The proposed NFMI method is based on the T2MI protocol from DVB-T2. T2MI is a method proposed that enables Single Frequency Network (SFN). It uses IP transmission to transmit a T2 frame to a modulator situated nearby or far away in order to make SFN possible. NFMI includes these characteristics, in addition to a protocol that can send converged service support information to the modulator. The structure of NFMI is as shown in Figure 5. Its packet types are shown in Table 3.

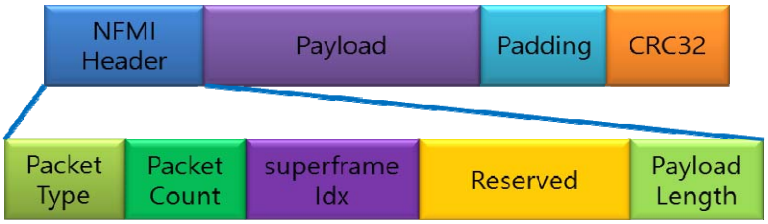

Figure 5. Structure of NFMI

Table 3. NFMI Type

NFMI Type	Description
00_{16}	Network Free Frame Data
01_{16}	Auxiliary Stream I/Q Data
10_{16}	Signal Info. Data
20_{16}	Timestamp for Converged Data
21_{16}	Individual addressing Data
40_{16}	Converged Data for Modulator
41_{16}	Network Free Structure Info.
Other values	Reserved for future use

3.3. Realization Result

Figure 6 shows the software implementation of the proposed multiplexing system capable of supporting converged services. The implemented multiplexer receives TS or IP based GSE, MMT as input, and can configure converged broadcasting system transmission parameters based on the next-generation European broadcasting system DVB-T2. The frame generated for converged broadcasting has a structure that can be transmitted to a modulator through file, ASI, or Ethernet.

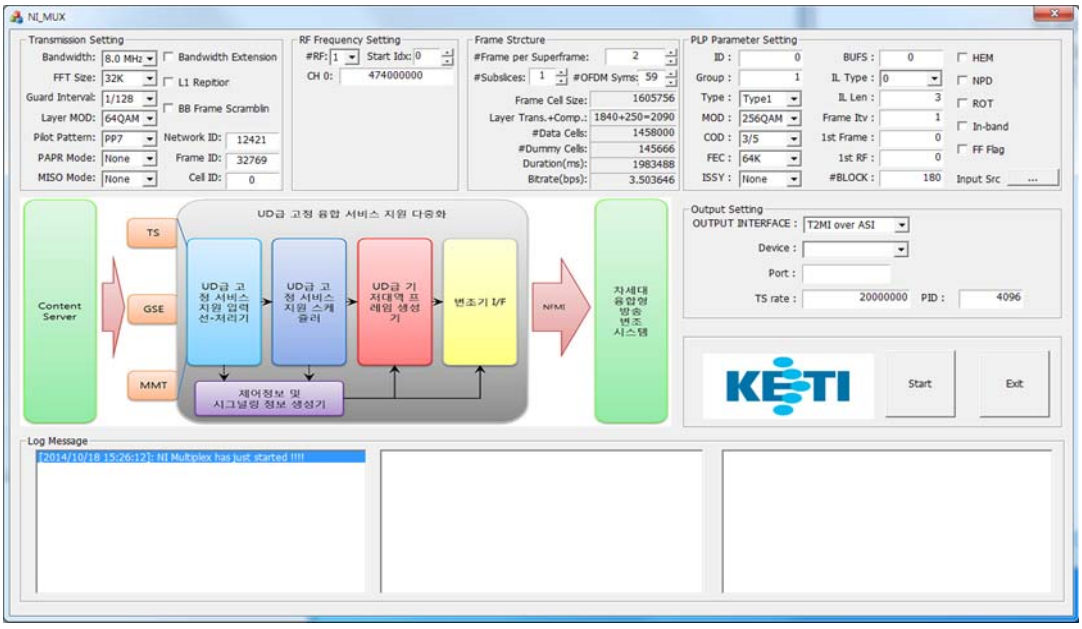

Figure 6. Multiplexing system that supports fixed/mobile converged services

The verification of the multiplexing system that uses the multiplexing method proposed in this paper is done by checking the normal operation of a commercial DVB-T2 receiver processing UHD contents transmitted, as shown in Figure 7.

The multiplexing receiver system is implemented using the API of the commercial receiver. HEVC decoder is used for 4K UHD contents replay. The transmission parameters for fixed/mobile converged services and frame composition information are also checked to verify the structure of the converged service frame received.

Figure 7. Screen showing 4K UHD contents for reception verification

4. CONCLUSION

In this paper, the design and implementation of a multiplexing system capable of fixed and mobile convergence services based on the next-generation European terrestrial broadcasting system is presented. In addition to UHD broadcasting which has been receiving the attention as stationary broadcasting service, technology relevant to multiplexer that can provide high quality service in mobile broadcasting service has been accumulated. The single platform developed can serve as a basis for a system that can provide converged stationary and mobile services as well as new additional services. As a next step, transmission and reception conformance testing on diverse forms of stationary and mobile services using UHD class contents will be performed.

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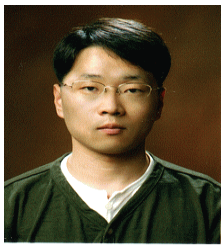

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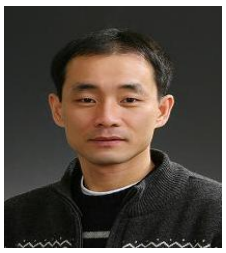

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