Design and Implementation of the Ensemble Remultiplexer for DMB Service Based on Eureka-147

Byungjun Bae, Joungil Yun, Sammo Cho, Young Kwon Hahm, Soo In Lee, and Kyu-Ik Sohng

ABSTRACT—A new transmission system is necessary for the Digital Multimedia Broadcasting (DMB) service in Korea. Therefore, in this paper, we propose a new architecture for the implementation of a DMB transmission system based on Eureka-147. We describe the design and implementation of the Ensemble remultiplexer, which is essential to the proposed system for remultiplexing ETI frames and MPEG-2 transport streams. The proposed system provides a solution with high flexibility and low cost for multimedia broadcasting service. The functions of this transmission system have been verified by using our DMB receiver and other related systems.

Keywords—Digital Multimedia Broadcasting, MPEG-2 TS, Ensemble remultiplexing, ETI frame reconstruction.

I. Introduction

The quality of traditional analog radio broadcasting systems has significantly deteriorated in recent years due to the serious electromagnetic pollution in urban areas, especially in mobile environments. Among the new emerging broadcasting systems, Digital Audio Broadcasting (DAB), which is based on the Eureka-147 standard, provides CD-quality audio broadcasting service for fixed, portable and mobile applications and has been recognized as a promising solution [1], [2]. Recently, the DAB system was announced as an official transmission specification of the Digital Multimedia Broadcasting (DMB) system in Korea. The DMB system provides various multimedia data services including moving pictures as well as CD-quality digital audio services and is creating a relatively new value chain structure in the broadcasting network by categorizing it into service providers, multiplexers and network providers [3].

The DMB system, which is also based on the Eureka-147 standard, has a 2.3-Mbps data-delivery capability, which is sufficient for multimedia broadcasting services as well as CD-quality digital audio services. However, the data payload reduces to 1.5 Mbps when we take into account the overhead such as the bits needed for synchronization, error correction and multiplex configuration information [2]. Therefore, for multimedia broadcasting services at a low data-delivery transfer rate, it is desirable to adopt advanced video coding (AVC), which has a high-coding efficiency [4]. In Korea, the video and audio coding standards for a multimedia broadcasting service follow AVC and bit sliced arithmetic coding (BSAC), respectively [5]. And, as a system specification of multimedia broadcasting service, it was adopted that coded streams be wrapped into the MPEG-2 transport stream (TS) of an MPEG-2 as a system standard for synchronization and multiplexing [6].

In this paper, we propose the architecture of a new DMB transmission system for multimedia broadcasting service through the conventional DAB transmission system. The proposed system does not change the main structure of the

Manuscript received Mar. 08, 2004; revised May 10, 2004.

This work was supported in part by the Ministry of Information and Communication of Korea under the title of "The Development of SmarTV Technology."

Byungjun Bae (phone: +82 42 860 3888, email: 1080i@etri.re.kr), Sammo Cho (email: semo@etri.re.kr), Young Kwon Hahm (email: ykhahm@etri.re.kr), Soo In Lee (email: silee@etri.re.kr) are with Digital Broadcasting Research Division, ETRI, Daejeon, Korea.

Joungil Yun (email: sigipus@gist.ac.kr) is with the Department of Mechatronics, GIST, Gwangju, Korea.

Kyu-Ik Sohng (email: kisohng@ee.knu.ac.kr) is with the School of Electrical Engineering and Computer Science, Kyungpook National University, Daegu, Korea.

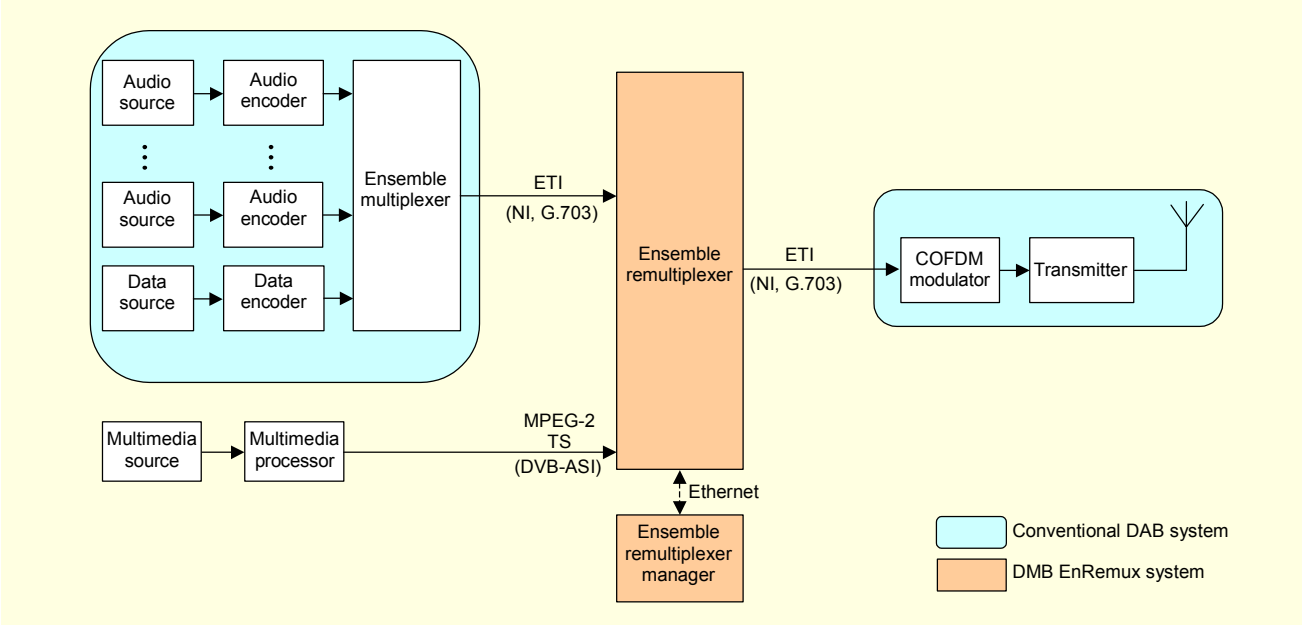

Fig. 1. The proposed DMB transmission system.

conventional DAB transmission system but simply adds a newly developed sub-system, which is called the Ensemble remultiplexer. This means that broadcasting stations and private enterprises which have already been equipped with the conventional DAB transmission system can reduce the cost of the DMB transmission system equipment for multimedia broadcasting service.

II. The Proposed DMB Transmission System

The proposed DMB transmission system, which is shown in Fig. 1, adds a multimedia processor and an Ensemble remultiplexer to the architecture of a conventional DAB transmission system.

The multimedia processor encodes the multimedia sources including video and audio which use AVC and BSAC coding standards, and outputs the encoded streams as an MPEG-2 TS. Actually, the proposed DMB transmission system may be used for a multimedia broadcasting service that uses any coding method of a multimedia source if the output of the multimedia processor is an MPEG-2 TS. That is, although the coding method of the multimedia source is changed, the proposed DMB transmission system is compatible.

The Ensemble remultiplexer, which receives Ensemble transport interface (ETI) frames from the Ensemble multiplexer and the MPEG-2 TS from the multimedia processor, reconstructs new ETI frames and sends them to the coded orthogonal frequency division multiplexing modulator [7]. The Ensemble remultiplexer also has additional blocks such as a Reed Solomon (RS) encoder and convolutional interleaver for the MPEG-2 TS to improve error protection [8].

A Digital Video Broadcast Asynchronous Serial Interface (DVB-ASI) is used as a physical interface between the multimedia processor and Ensemble remultiplexer to steadily transmit the MPEG-2 TS.

III. Ensemble Remultiplexer

Figure 2 shows the architecture of the Ensemble remultiplexer. The Ensemble remultiplexer consists of two parts:

i) a hardware part, which includes an ETI input module, MPEG-2 TS input module, ETI output module, field-programmable gate array (FPGA) module, and CPU module (MPC860), and

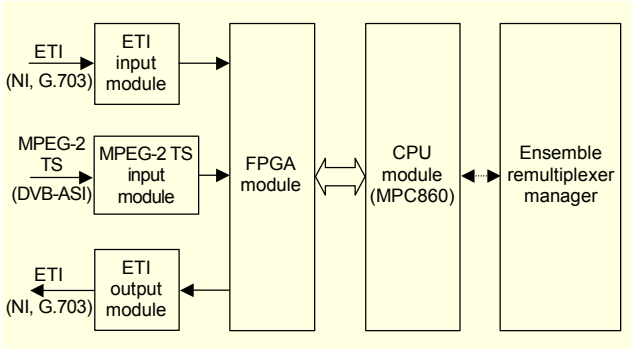

Fig. 2. The architecture of the Ensemble remultiplexer.

ii) a software part, which includes an application software layered on the CPU module and a monitoring and controlling program implemented in a personal computer.

The main functions of the Ensemble remultiplexer are done in the FPGA module and the application software in the CPU module.

1. FPGA Module

Figure 3 shows the functional blocks of an FPGA Module. An ETI frame receiver constructs and verifies valid ETI frames by checking the two types of synchronization field, i.e., $073AB6_{16}$ and $F8C549_{16}$, which are consecutively detected by turn every 24 ms. An MPEG-2 analysis block multiplexes a null packet with the TS received from the TS receiver block by counting the number of bytes per second to make the bit rate of the TS be a desired constant value given by the CPU module through the command processor block. To transmit an MPEG-2 TS robustly, the RS (204, 188, t=8) shortened code, which is derived from the original systematic RS (255, 239, t=8) code, and the convolutional byte-interleaving with a depth of I=12 are applied in the outer coder block.

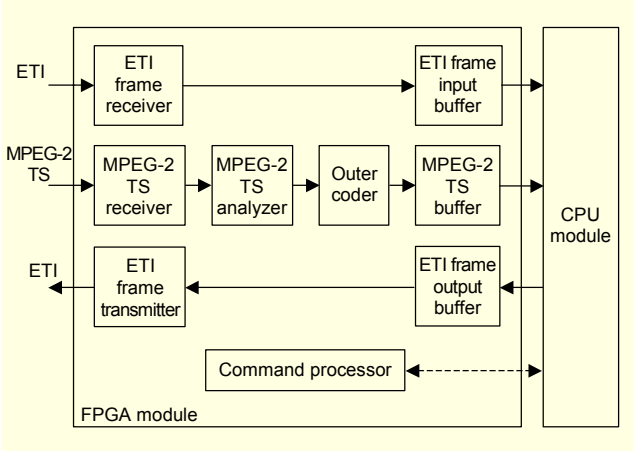

Fig. 3. The architecture of the FPGA module.

2. Application Software

The application software is an embedded program that runs on the MPC860 CPU module to analyze and reconstruct ETI frames. As shown in Fig. 4, it mainly consists of three managers and the ETI frame data group.

An analysis manager gets an ETI frame from the ETI frame input and analyzes it. After the ETI frame is analyzed, it is segmented into each part of the ETI frame data group. The ETI frame data group is a group of data in which the main stream (MST) data, the stream characterization (STC), the frame characterization (FC) field, and the synchronization (SYNC) field are separated. An encoded TS packet of data bytes with a desired sub-channel stream length (STL) is inserted in the MST data, and a corresponding sub-channel stream characterization (SSTC) is also inserted in the STC data. The message manager communicates with the command processor and reconstruction manager to control (or monitor) the FPGA module and to manage the reconstruction processing. A DMB system operator can connect the message manager through TCP/IP to operate the system with an Ensemble remultiplexer manager on a PC. With the ETI frame data group and setting data from the message manager, the reconstruction manager reconstructs the appropriate ETI frames and sends them to the ETI frame output.

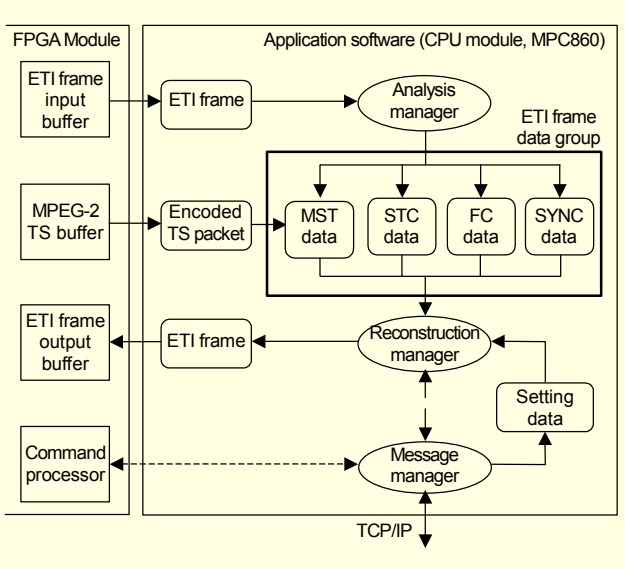

Fig. 4. The structure of the application software on a CPU module.

3. Ensemble Remultiplexer Manager

The Ensemble remultiplexer manager on a PC is operated as a user interface. The interface software is used to reconfigure the program and to monitor the channel status. This manager provides the following primary functions: i) read the status of the input channels, ii) modify the channel status, iii) provide information to generate the fast information channel and reconstruct the ETI frame header, and iv) command the addition and removal of the sub-channels.

IV. Experimental Results

We verified the proposed DMB transmission system for a multimedia broadcasting service under the experimental conditions shown in Table 1. The coding rates of video and

audio are 512 kbps and 96 kbps by MPEG-4 AVC and MPEG-4 BSAC, respectively.

The coded video stream has 15 frames per second and the protection level is 3-A, which is an equal error protection with code rate 0.5. Digital multimedia broadcasting using the proposed system is transmitted with a 40-W transmitter output power using an omni-directional antenna at a site in ETRI, Korea. We checked the reception condition of multimedia broadcasting from a moving bus.

From the result of this experiment, we could confirm that analog broadcasting is not normally displayed, but that digital multimedia broadcasting is displayed without any problem under the 80-km/h bus speed in the coverage area within a 4- to 5-km radius.

Table 1. The experimental condition.

Frequency		201.072 MHz
Transmitter output		40 W
Multimedia stream	Video	MPEG-4 AVC 512 kbps, 15 fps
	Audio	MPEG-4 BSAC 96 kbps
	System	MPEG-4 & MPEG-2
Protection level		3-A (1/2)

V. Conclusions

We proposed the new architecture of a DMB transmission system based on Eureka-147 for a multimedia broadcasting service. To remultiplex ETI frame data from a conventional DAB multiplexer and MPEG-2 TS, we designed the Ensemble remultiplexer. Each module of the Ensemble remultiplexer is described and implemented in this paper.

The proposed system provides a solution with high flexibility and low cost to service multimedia broadcasting by using the conventional DAB transmission system. The experimental broadcasting of a DMB service, which is based on the proposed transmission system using our Ensemble remultiplexer, is planned to start in Korea in 2004.

Acknowledgment

We would like to thank the anonymous reviewers, whose comments improved this paper.

References

[1] B. Roscher, H. Weissleder, G. Fuchs, H. Kling, and M. Isken, "Experiences in the Design of DAB Front-Ends," *IEEE Proc. Consumer Electronics*, June 1998, pp. 386-387.

[2] ETSI EN 300 401 v1.3.3, *Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to Mobile, Portable and Fixed Receivers*, Sept. 2001.

[3] Wolfgang Hoeg and Thomas Lauterbach, *Digital Audio Broadcasting, Principles and Applications*, John Wiley & Sons, 2001.

[4] ITU-T Rec. H.264 | ISO/IEC 14496-10 *AVC: Advanced Video Coding for Generic Audiovisual Services*, Mar. 2003.

[5] ISO/IEC 14496-3, *Information Technology – Coding of Audio-Visual Objects*, Part 3: Audio, Dec. 1999.

[6] ISO/IEC 13818-1, *Information Technology – Generic Coding of Moving Pictures and Associated Audio Information: System*, Dec. 1997.

[7] ETSI ETS 300 799, *Digital Audio Broadcasting (DAB); Distribution Interface, Ensemble Transport Interface (ETI)*, Sept. 1997.

[8] ETSI EN 300 744, *Digital Video Broadcasting (DVB); Framing Structure, Channel Coding and Modulation for Digital Terrestrial Television*, July 1999.

[9] DVB Document A055, *Implementation Guidelines for the Asynchronous Serial Interface*, 2000.