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Evaluation of the T-DMB Standard and the Transmission System by Using Ensemble Remultiplexer

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SUMMARY This paper briefly introduces the T-DMB standard based on Eureka-147 DAB and presents a new T-DMB transmission system, which uses a device called the Ensemble Remultiplexer, for mobile multimedia broadcasting service. And we verify the T-DMB standard by using the new transmission system with commercial equipment in the laboratory and in the field as moving on a car in high speed around urban districts surrounded by high buildings.

1. Introduction

Digital audio broadcasting (DAB), which is based on Eureka-147 standard, provides CD quality audio broadcasting service for fixed, portable and mobile applications and has been recognized as a promising solution for the next digital mobile broadcasting system [1], [2]. Since the Eureka-147 DAB system was announced in the middle of 1990s, many kinds of applications have emerged in many countries around the world [3], [4]. Among them, terrestrial digital multimedia broadcasting (T-DMB) is a new application for mobile multimedia services based on Eureka-147 DAB system. Officially, T-DMB was announced as a standard for mobile digital broadcasting in Korea in the middle of 2004 [5]. And the World Forum for DAB adopted T-DMB as a global standard in December 2004. T-DMB is mainly focused on the broadcasting of moving pictures and their reception in harsh environment such as urban areas surrounded by high buildings or highways where vehicles are moving at a high speed, and further, data broadcasting is also possible through T-DMB by using digital broadcasting technologies. Therefore, T-DMB could provide various multimedia broadcasting services including moving pictures as well as CD quality digital audio services while moving.

As shown in Fig. 1, T-DMB is standardized by adding new functions to Eureka-147 DAB such as a video coding and external protection algorithms [5]. For the multimedia service of T-DMB, MPEG-4 advanced video coding (AVC) and MPEG-4 bit sliced arithmetic coding (BSAC) are selected as the video and audio encoding standard, respectively [6], [7]. It also supports data broadcasting that enables interactive dialogue via MPEG-4 binary format for scene (BIFS). For multiplexing and streaming, each MPEG-4 media is firstly encapsulated into MPEG-4 sync layer (SL) packets. MPEG-4 SL provides synchronization information for the MPEG-4 multimedia contents in a flexible structure. Then, MPEG-4 SL-packetized elementary streams are encapsulated in an MPEG-2 transport stream (TS) after packetized elementary stream (PES) process and then Reed-Solomon (RS) encoding and convolutional byte-interleaving are used to improve the error protection [8]. These processes cause the bit error rate (BER) level to be below \(10^{-8}\). Generally, the Eureka-147 DAB system guarantees the BER level of \(10^{-4}\) by using the inner channel coding such as convolutional interleaving. The data structure of RS encoded MPEG-2 TS packets is shown in Fig. 2(a) and convolutional byte-interleaving algorithm used for T-DMB multimedia service is explained in Fig. 2(b). RS encoding uses code generator polynomial \(G(x) = (x + \lambda^8)(x + \lambda^3)(x + \lambda^2)(x + \lambda^{15})\) where \(\lambda = x^{15}\) and field generator polynomial \(P(x) = x^8 + x^4 + x^3 + x^2 + 1\), and 16 parity bytes are added at the end of the 188-byte MPEG-2 TS. The convolutional byte-interleaving algorithm uses 12 branches in the process of convolutional byte-interleaving. Finally, the outer coded MPEG-2 TS is carried in a sub-channel as one of the stream mode services and that is transmitted through the Eureka-147 DAB based transmission system.

Fig. 1 Standard structure of T-DMB the multimedia service.

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In this paper, we present a new architecture of transmission system, which uses a new device called the Ensemble Remultiplexer, for mobile multimedia broadcasting service. We also verify the T-DMB standard using the transmission system using the Ensemble Remultiplexer in a field while moving on a car around urban districts as well as in a laboratory with monitoring and receiving equipment for T-DMB.

2. T-DMB Transmission System Using Ensemble Remultiplexer

The configuration of the T-DMB transmission system to verify the T-DMB standard, is shown in Fig. 3, which uses a new device named the Ensemble Remultiplexer. The Ensemble Remultiplexer remultiplexes MPEG-2 TS as well as ensemble transport interface (ETI) [9], which does not require changing the underlying structure of the conventional DAB transmission system [10]. This means that broadcasting stations or private enterprises already equipped with the conventional DAB transmission system could reduce the cost of equipment for the T-DMB service. Moreover, it is possible that the local ensemble providers who are provided with ensemble signal in ETI format from a main ensemble provider through a distribution network could produce a new ensemble signal for their own T-DMB service by using the Ensemble Remultiplexer [11].

ETI frame is a uniform stream with a fixed bit rate and remultiplexing ETI frames requires frame parsing, synchronized scheduling, service and information editing, and frame reconstructing processes [11]. To insert MPEG-2 TS for the multimedia service into the one of the sub-channels of ETI frames, it is necessary to control the bit rate of MPEG-2 TS stream data which is to be outer coded for error protection. Figure 4 shows the block diagram of bit rate control and outer coding of MPEG-2 TS. MPEG-2 TS received after synchronizing process are analyzed so that the bit rate of MPEG-2 TS is calculated excepting null packet and the information is sent to managing block. By using this information and sub-channel size configured in advance, the managing block calculates the exact amount of data to be remultiplexed with per ETI frame period (24 ms). The packet rate control block supplies MPEG-2 TS by RS packet unit (204 bytes) to outer coder block and it makes stream buffer maintain the sufficient mount of streams without overflow or underflow.

The algorithm used for controlling bit rate of MPEG-2 TS which is buffered at the packet rate control block and outer coded is summarized as follows:

a) The byte size of the sub-channel in which the outer coded MPEG-2 TS will be carried for the multimedia service can be calculated by using the bit rate of the sub-channel, $B_{sc}$, and ETI frame period, 24, as follows [9]:

$$S = \frac{B_{sc} \times 24}{8} \quad (1)$$

b) To calculate the number of packets, $N_i$, written to the buffer during the $i$-th ETI frame period, divide the byte size of sub-channel, $S$, by the byte size of a RS encoded MPEG-2 TS packet, 204, as follows:

$$N_i = \frac{S}{DIV204} \quad (2)$$

where DIV denotes integer division.
c) Accumulate the remainder of the division, $R_i$, at $R$ as follows:

$$ R = R + R_i $$

where $R_i = S \mod 204$.

d) If $R > 204$, it means that the number of packets buffered during the $i$-th ETI frame period is increased by 1. Then, the number of packets $N_i$ that would be buffered at the packet rate control block and the reminder $R$ during the $i$-th frame period is updated as follows:

$$ N_i = N_i + 1 $$

$$ R = R - 204 $$

e) At the end of the $i$-th frame period, the number of packets to be buffered are controlled according to the value $N_i$ so that the output bit rate of the outer coder is constant.

3. Verification of the T-DMB Standard and the Transmission System

We verified the T-DMB standard and the T-DMB transmission system, that we present, by constructing various systems for the experimental condition as shown in Fig. 5. And Fig. 6 shows the Ensemble Remultiplexer which was designed and implemented to be used in this paper.

At first, we tested the remultiplexing method with a commercial ETI monitor in the laboratory. Figure 7 shows the ensemble service information displayed by the ETI monitor. As shown in Fig. 7(a), ETI frames inputed into Ensemble Remultiplexer has two audio services. By controlling Ensemble Remultiplexer manager, we removed an audio service labeled ‘Audio Service 2’ and inserted a new multimedia service labeled ‘DBM Service.’ Figure 7 (b) shows the ensemble information of the outputed ETI frames. As a result of testing, we can see that the reconstructed ETI frames does not have any problems.

We also tested the presented T-DMB transmission system several times to verify the effect of T-DMB under the experimental condition as shown in Table 1. Video and audio sources were encoded by MPEG-4 AVC of 384 kbps and MPEG-4 BSAC of 96 kbps, respectively and then they were encapsulated into an MPEG-2 TS of 512 kbps. The resultant digital multimedia broadcasting signal is transmitted from the transmitter, which has the output power of 2 KW, at the broadcasting station site in Kwanak Mountain in Seoul.

We equipped antennas for analog TV and DMB TV on top of the test bus and also, we fixed the analog TV and T-DMB experimental decoder in the vehicle with some measurement equipment like spectrum analyzers. The analog TV receives the normal NTSC TV signal from the broadcasting site while the T-DMB experimental receiver receives...
the T-DMB signal from the transmitter, which is converted to the T-DMB signal from the same analog TV signal.

The quality of the received signal is shown in Fig. 8. Figure 8(a) shows the reception quality of analog TV (NTSC in Korea) and Fig. 8(b) shows that of T-DMB TV. Although at the start location both of the pictures were in good condition, the picture of the analog TV degraded rapidly as the vehicle reached up to normal speed. And in the areas where high buildings and many cars were surrounding the test vehicle, the signal quality became even worse, while the pictures in T-DMB TV maintained good condition.

4. Conclusions

The experimental results show that the presented T-DMB transmission system successfully transmits the moving picture signal through the narrow digital audio channel. We verified the T-DMB standard for mobile broadcasting services by using the presented system.

In the near future, T-DMB is expected to provide mobile multimedia broadcasting services at anytime and anywhere at reasonable costs. Not only that, T-DMB will offer diverse application services and evolve continuously, thereby making life far more convenient.

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