# Hierarchical Transmission Algorithm combined coding method in the T-DMB system

Jongtae Bae[1], Minhyuk Kim[2], Suksoon Choi[3], Taedoo Park[4], Namsoo Kim[5], and Jiwon Jung[6]
Department of Radio Communication Engineering, Korea Maritime University
#1, Dongsam-dong, Youngdo-gu, Busan, Korea
E-mail: [1]ms43bjt@hhu.ac.kr, [2]squru@hotmail.com, [3]next_jeonpa@hhu.ac.kr,
[4]bokddori@hhu.ac.kr, [5]skatn1983@hhu.ac.kr, [6]jwjung@hhu.ac.kr

Abstract: T-DMB (Terrestrial Digital Multimedia Broadcasting) system, is based on the Eureka-147 standard, provides various multimedia data services. However T-DMB needs more various services and higher throughput while maintaining reception. Therefore, this paper proposes advanced T-DMB system using the unequal error protection system, hierarchical multi level modulation and various coding scheme which is used for recent wireless communication, while maintaining backward compatibility. As the simulation results, proposed advanced T-DMB system has coding gain of 2~6dB compared to conventional T-DMB.

## 1. Introduction

The DMB system 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 1.5Mbps when we take into account the overhead such as the bits needed for synchronization, error correction and multiplex configuration information. Therefore, for multimedia broadcasting services at a low data-delivery transfer rate[1][2].

However, many users want more various services. And new technology may have been developed to allow higher throughput and to guarantee more reliable reception. Thus it is necessary to upgrade T-DMB system[3].

Thus, in this paper, a hierarchical modulation scheme and unequal error protection are applied to the conventional T-DMB system for the backward compatibility.

## 2. Unequal Error Protection(UEP) system and Hierarchical modulation

Some parts of information are more important than that in the other parts. Therefore, stronger protection should be applied to these parts than to the other parts. This is unequal error protection(UEP). Fig. 1 shows general UEP system block diagram[4].

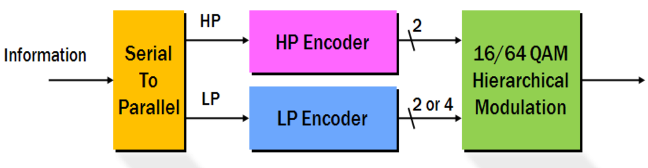



Figure 1. General UEP system block diagram.

This work was supported by Defense Acquisition Program Administration and Agency for Defense Development under the contract UD070054AD

Fig. 2 shows proposed coding scheme using UEP method for advanced T-DMB in this paper. HP(High Priority) can be used for conventional T-DMB system, and LP(Low Priority) is used for additional service.

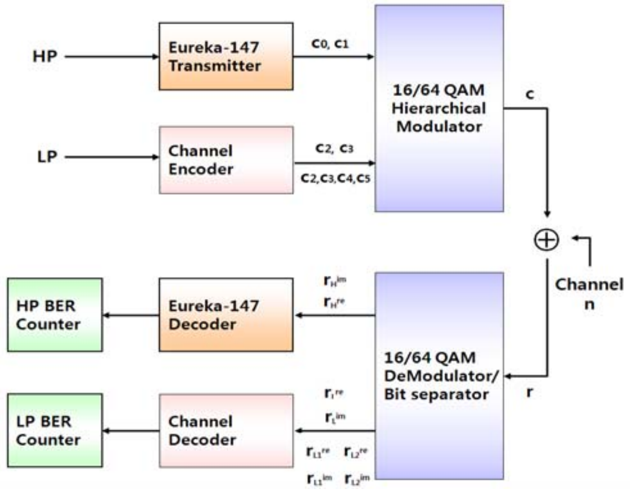



Figure 2. Proposed advanced T-DMB UEP system model.

In hierarchical modulation, two separate data streams are modulated onto a single stream[5]. The data streams of hierarchical modulation vary in their susceptibility to noise. In other words, the service coverage areas differ in size. Receivers with "good" reception conditions can receive both streams, while those with “poorer” reception conditions may only receive the HP stream[6].

Fig. 3 and fig. 4 show proposed unequal 16QAM and 64QAM hierarchical modulation constellation for advanced T-DMB.

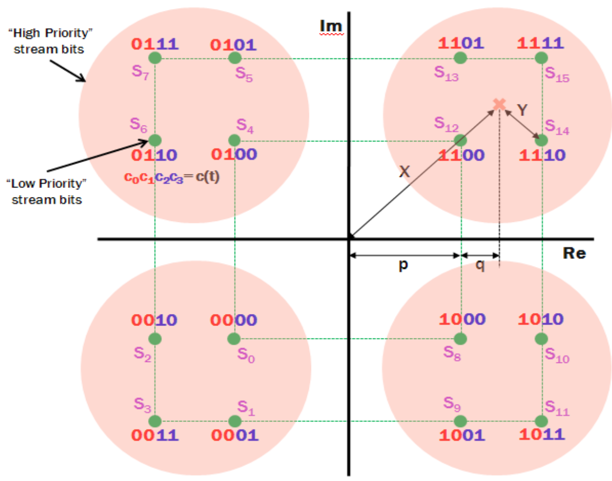



Figure 3. Proposed unequal 16QAM hierarchical modulation constellation.

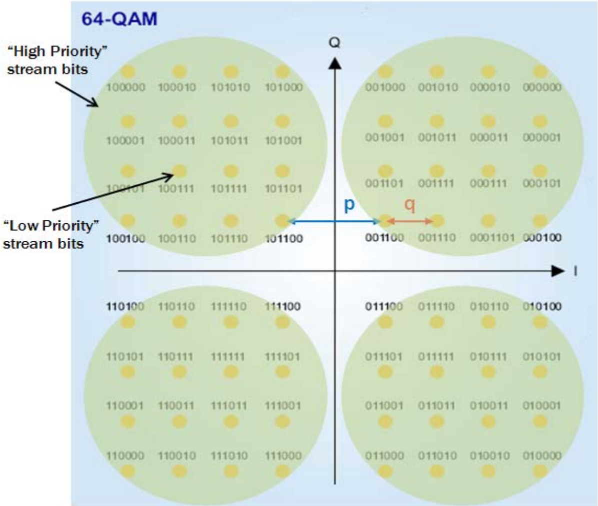



Figure 4. Proposed unequal 64QAM hierarchical modulation constellation.

Let α is the ratio between symbols of unequal 16QAM and 64QAM, α is shown in equation (1).

$$\frac{p}{q} = \alpha \tag{1}$$

## 3. Bit split method

Multilevel modulation has become an essential field of research in digital communications. However, all those advantage of iterative codes should be accompanied with accurate estimation of soft demapping of the received signal. This would be more important in the decision input from a received signal includes many complex computing operations[7].

Recently, there are various methods as LLR method, MAX method, and Euclidian distance method. In this paper, we propose bit split method for advanced T-DMB system.

For example, in 16QAM mdulation of fig. 3, received signal, r(t) is calculated from equation (2), where c(t) and n(t) denote the transmitted signal and the noise signal.

$$r(t) = c(t) + n(t) \tag{2}$$

Let $r_I(t)$ is inphase value of r(t) and $r_Q(t)$ is quadrature value of r(t). And then, each decoder input signal value is calculated from equation (3) ~ (6).

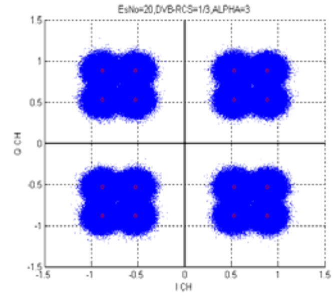
$$r_{aI}(t) = r_I(t) \tag{3}$$

$$r_{aQ}(t) = r_Q(t) \tag{4}$$

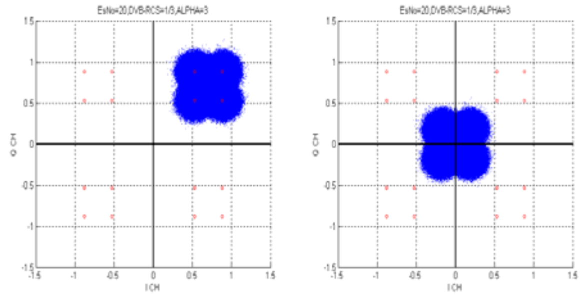
$$r_{tI}(t) = |r_I(t)| - (p+q) \tag{5}$$

$$r_{tQ}(t) = |r_Q(t)| - (p+q) \tag{6}$$

Fig. 5 shows process of bit separation using receive signal in the AWGN channel in case of α=3 and EsNo=20dB.




(a) Receive signal




(b) LP signal constellation after bit split

Figure 5. Process of bit separation

## 4. Simulation result

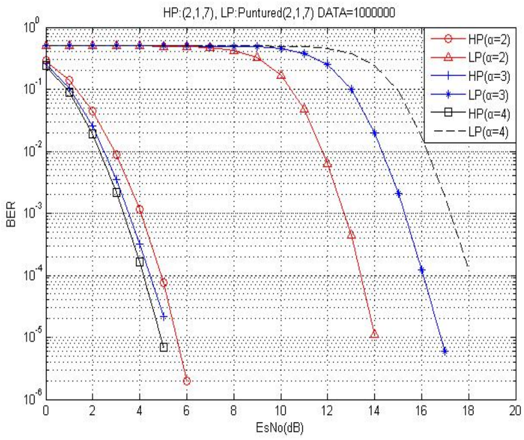
We simulated the performance HP and LP data in AWGN channel. Table 1 shows simulation parameters of used various HP and LP coding methods. Punctured convolution code(T-DMB spec.) and binary turbo code are simulated only at 16QAM modulation method.

Table 1. Simulation parameters

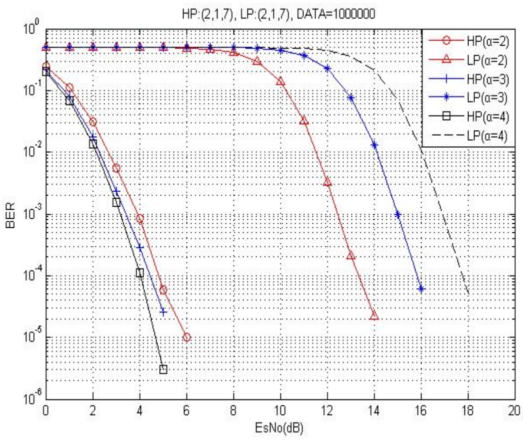
| | | | |
|---|---|---|---|
| HP | Convolutional code | G(x) | $(171,133)_8$ |
| | | Coding Rate | 1/2 |
| LP | Convolutional code (T-DMB) | G(x) | $(133,171,145,133)_8$ |
| | | Coding Rate | 1/2(punctured) |
| | Binary Turbo code | State | 4 or 8 |
| | | Block size | 1536 |
| | | Iteration | 5 |
| | | Coding Rate | 1/2 |
| | Double Binary Turbo code (DVB-RCS) | Block size | 1536 |
| | | Iteration | 5 |
| | | Coding Rate | 1/2,1/3,1/4 |
| | LDPC code | Block size | 16200(K=7200) |
| | | Iteration | 70 |
| | | Coding Rate | 1/2 |

Fig. 6(a) shows the simulation result in terms of the value of α in case that (2,1,7) convolution code is used for HP and LP data. At the BER of $10^{-4}$, the coding gain difference is more than about 9dB between HP and LP BER performance. When the value of α is larger, the HP performance is the better but LP performance is worse.

Fig. 6(b) shows the BER performance when (2,1,7) convolution code is used for HP data and punctured (2,1,7) convolution code is used for LP data. The result of BER performance is almost the same as fig. 6(a).



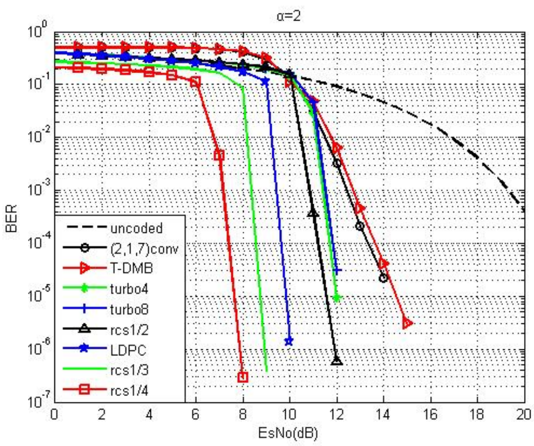

(a) HP:(2,1,7) convolution code,
LP:(2,1,7) convolution code



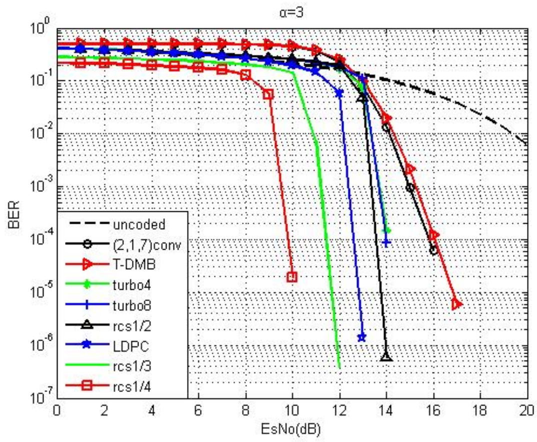

(b) HP:(2,1,7) convolution code,
LP:punctured (2,1,7) convolution code

Figure 6. Comparison of BER performance between HP and LP data in case of 16QAM.

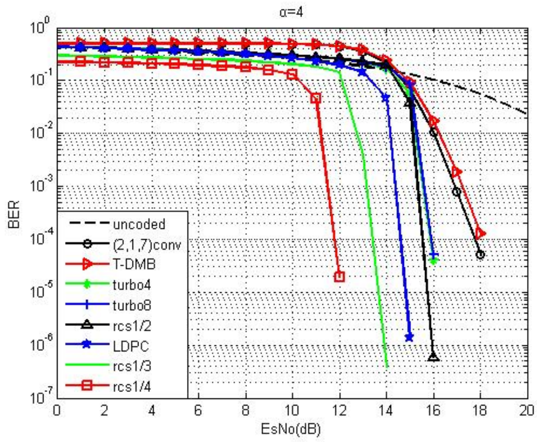
Fig. 7 shows BER performances of LP data using various coding methods in case of 16QAM modulation method. At the BER of $10^{-4}$, LDPC code with half rate is better than conventional T-DMB as about 4dB and double binary turbo code with R=1/4 is better than conventional T-DMB as about 6dB.




(a) α=2




(b) α=3




(c) α=4

Figure 7. BER performances of LP data using 16QAM.

Fig. 8 shows BER performance of HP and LP data using 64QAM modulation in case that (2,1,7) convolution code is used for HP and LP data.

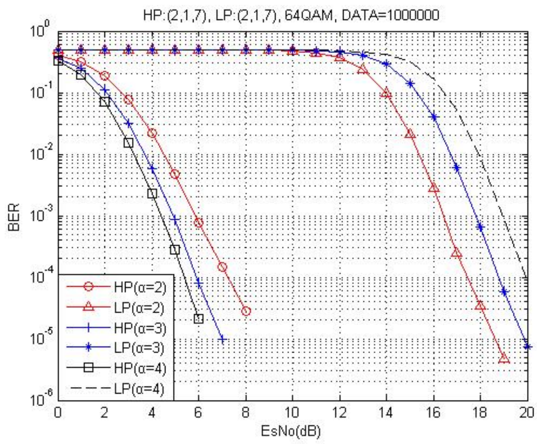
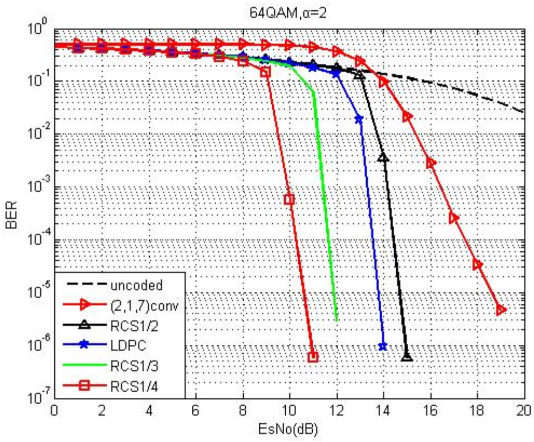
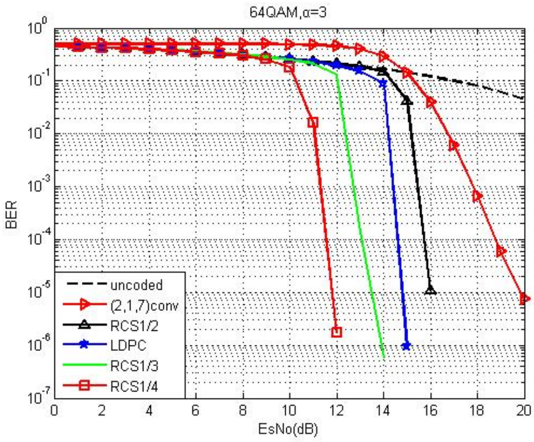



Figure 8. Comparison of BER performance between HP and LP data in case of 64QAM.

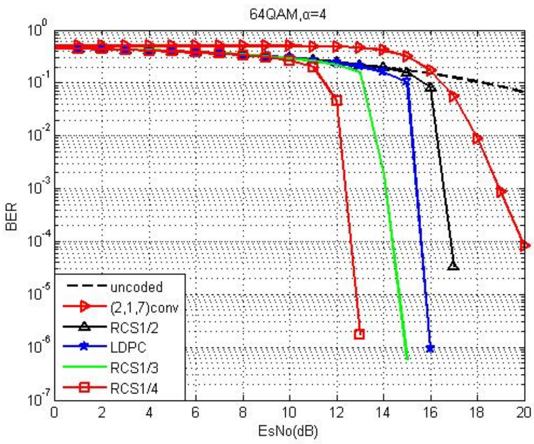
Fig. 9 shows BER performances of LP data using various coding methods in case of 64 QAM modulation method. Although the BER performance is some different, fig. 9 is similar with fig. 7.




(a) α=2




(b) α=3




(c) α=4

Figure 9. BER performances of LP data using 64QAM.

## 5. Conclusion

As the results of simulation, when the value of α is larger, the HP performance is the better, but LP performance is worse. This is the reason that the value of α is larger, the adjacent mapping points of LP data are closer, and adjacent mapping point of HP data are farther.

For high data rate, T-DMB system can use 16QAM and 64QAM modulation scheme without more power consumption.

At the BER of $10^{-4}$, proposed advanced T-DMB in this paper has coding gain of 2~6dB compared to conventional T-DMB.

## References

[1] ETSI EN 300 401 ver. 1.3.3 "Radio Broadcasting Systems; Digital Audio Broadcasting(DAB) to mobile, portable and fixed receivers", May. 2001.

[2] B.Bae, et. Al, "Design and Implementation of the Ensemble Remultiplexer for DMB Service Based on Eureka-147." ETRI Journal, vol. 26, no. 4, pp. 367-370, Aug. 2004.

[3] Hyung Taek Lim, Sang Hoon Lee and Eon Kyeong Joo "Performance of Concatenated code with hierarchical modulation in T-DMB system.", ICECE 2006, pp. 282-285, Dec. 2006.

[4] L.F. Wei, "Coded modulation with unequal error protection.", IEEE Trans. Commun., vol. 41, pp.1439-1449, Oct. 1993.

[5] Jeff Gledhill, Peter Macavock, Roger Miles, "DVB-T; Hierarchical Modulation", DVB, March 2000.

[6] A. Schertz and C. Weck, "Hierarchical modulation – the transmission of two independent DVB-T multiplexes on a single frequency", EBU Techn., April 2003.

[7] Jin Hee Jeong, Duk Gun Choi, Min Hyuk Kim, and Ji won Jung, "Optimal Soft Symbol Split Methods and Performance Analysis for Applying to Multilevel Modulation of Iterative Codes", APCC 2006, Aug. 2006.

[8] ETSI EN 301 790 ver. 1.3.1 "Digital Video Broadcasting(DVB); Interaction channel for satellite distribution systems", March 2003.