

Design of Downlink Control Channels for MHN Enhanced System

Dae-Soon Cho[†], Ilgyu Kim[†]

[†] Mobile Application Research Department

Electronics and Telecommunications Research Institute

Daejeon Korea dscho@etri.re.kr,

igkim@etri.re.kr

Abstract—In spite of the high need for high data rate for users, there has been no wireless mobile backhaul system supporting 10Gbps data rate for fast moving group vehicle such as a subway and a train. In ETRI, we have been designing and developing MHN-E (Mobile Hotspot Network - Enhanced) system to meet the criteria which is focused on fast moving vehicle. MHN-E system supports up to 10Gbps downlink data transmission rate for fast moving group vehicle. Supported moving velocity is considered up to 500km/h. In this paper, downlink control channel structures of MHN-E system are described and their performances are shown.

Keywords—Control Channels, MHN-E, Millimeter Wave, Multiflow.

I. INTRODUCTION

4G (4th generation) LTE/LTE-A mobile communication systems are currently commercialized [1][2]. However, it is sure that higher data transmission rate will be required over the short haul. In order to meet this data rate, work to specify 5G (5th generation) mobile communication system is under way and development is also in progress. It is essential to employ wider band to improve data transmission rate. As there is not enough space in cellular band, which is almost saturated, most of researchers and developers are considering millimeter wave band to apply in 5G system [3][4].

There has been few system that considers both high data transmission rate and high-speed mobility. 4G LTE and LTE-A systems are also designed and developed with the target of low speed mobility. These are not suitable for fast moving group vehicle such as high-speed train. Data usage with smart phones and tablets of many passengers in group vehicle such as a bus, a train and a subway is increasing very deeply. However, there is no wireless mobile backhaul system to cover these requirements. It is necessary to develop a wireless mobile backhaul system that is suitable for fast moving environment.

In ETRI (Electronics and Telecommunications Research Institute), we have developed MHN (Mobile Hotspot Network) system by Feb. 2016 to satisfy the requirement that is stated above [5][6]. MHN system supports up to 1Gbps

downlink data transmission rate. However, we think that this throughput will be saturated soon. Therefore, we are preparing the next version of MHN system, MHN-E (MHN – Enhanced) system, to stand against saturated environment [7][8][9]. This system supports 10Gbps downlink transmission data rate with the mobility up to 500 km/h. In this paper, we describe the structure and verify the performance of downlink control channels in MHN-E system

This paper is organized as follows. In section II, features of MHN-E system that has been designed and developed in ETRI are described in brief. In section III, structure and features of downlink control channels of MHN-E system are shown. The differences of downlink control channels between MHN and MHN-E systems are depicted. In section IV, we simulated the performance of downlink control channels in MHN-E system are shown. Finally, we concluded this paper in section V.

II. MHN-E SYSTEM

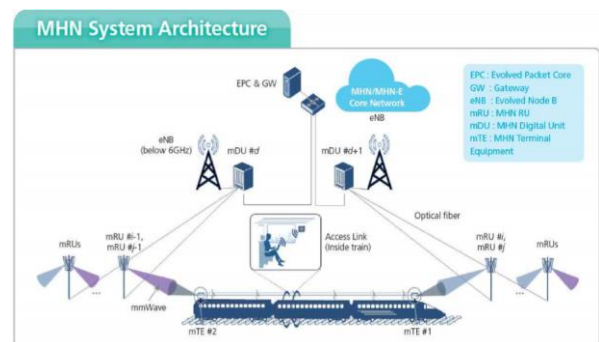


Figure 1. MHN-E System Architecture

In this section, we describe some features of MHN-E system. MHN-E system is a two-tier system. The first tier is the mobile wireless backhaul link, which uses millimeter band, supports up to 10Gbps performance and is also the core part of MHN-E system development. The second tier is the access link inside the moving group vehicle such as a train and a subway, where Gbps data transmission is served to passengers using Wi-Fi and/or LTE-A Femto networks. This means that end users can use Gbps data service with their smart phones, tablets and notebooks.

MHN-E wireless mobile backhaul technology is state-of-the-art technology, which is over 1000 times faster than existing Wibro-based wireless mobile backhaul technology. This means that thousands of users can download HD video streams at the same time in MHN-E system.

TABLE I. MHN-E SYSTEM FEATURE

Parameters	Values
System Bandwidth	Max 1GHz
Carrier frequency	27 GHz
Duplex Mode	TDD/FDD
1 Radio Frame	40slots(10ms)
1 Slot (1 TTI)	40 OFDM symbols (250us)
Max. no. of RB	50
1 RB	12 subcarriers
1 subcarrier	180kHz
FFT	1024

Several core techniques such as CA(carrier aggregation), FD-MIMO and SFMF (Single Frequency Multi Flow) are adopted. Maximum bandwidth of MHN-E system is 1GHz, furthermore, two times of data rate has increased by applying FD-MIMO.

MHN-E system can support both TDD and FDD duplex mode. We decided the main duplex as TDD mode considering the frequency efficiency. Main numerology of MHN-E system is shown in table I.

A basic bandwidth of MHN-E system is 125MHz and can be extended up to 1GHz (125MHz x 8 FA), where FA means frequency allocation and therefore maximum 8 carrier aggregation is available. The unit of TTI (Transmit Time Interval) is 1 slot. In frequency domain, 1 Resource Block (RB) is composed of 12 subcarriers, where maximum number of supported RBs are 50. Subcarrier space are determined as 180kHz in the light of the environment with very high speed. Downlink control channels are placed at the first 2 consecutive OFDM symbols at every TTI, which are depicted in figure 2.

III. DOWNLINK CONTROL CHANNELS

There are 3 downlink control channels in MHN-E system. There are M-BCH (MHN-E Physical Broadcasting channel), M-DCCH (MHN-E Physical data control channel) and MHICH (MHN-E Physical H-ARQ indicator channel).

M-CFICH contains the information of number of OFDM symbols, which is removed in MHN-E system. As OFDM symbol number of downlink control channel resource is fixed to 2, therefore, M-CFICH is removed naturally to enlarge the resource allocation of M-DCCH. As MHN-E system is specialized to mobile group vehicles such as a train and a subway, number of accessed mTE is finite and 2 OFDM symbols is enough to total resource of control channels

In MHN-E system, 2x2 FD-MIMO structure is adopted. This has an effect that existing transmission rate of data channel

is increased double. Furthermore, as number of antenna is two, SFBC can be applied to downlink control channels. Performance can be double due to SFBC diversity. In downlink control channels of MHN-E system, SFBC is the default mode.

As all SFN (System Frame Number) 12 bits are included inside M-BCH, the feature of repetition of carrying the same M-BCH at every 4 frames is removed. This means that different MIB (Master Information Block) information is transmitted at every frame. Only 4 OFDM symbols are allocated to M-BCH in MHN-E system. As shown in figure 4, in spite of using 4 OFDM symbols, we can see the performance meets the required SNR because of SFBC diversity. FER simulation performance of M-BCH is shown in figure 4.

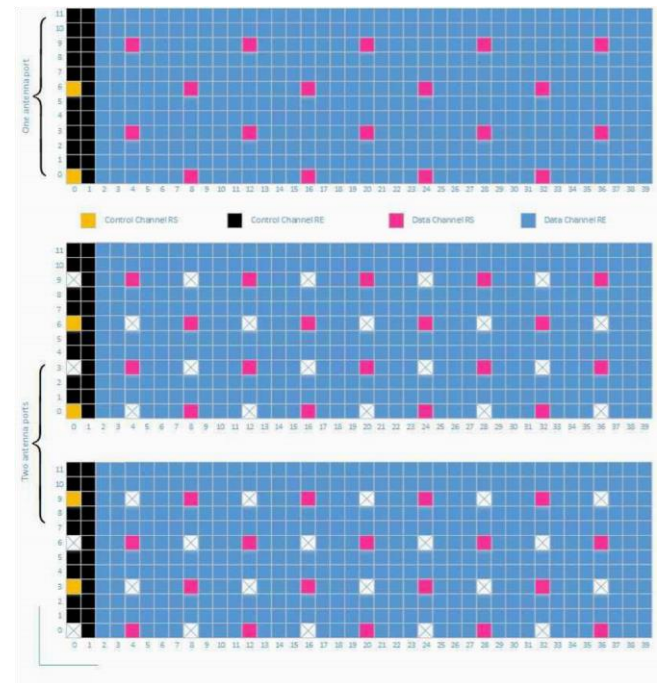


Figure 2. Resource Allocation of Channel Signals

The applicable number of CCE to M-DCCH is reduced from 16 to 8 and from 8 to 4. In spite of the reduction of CCE number, there is no loss in performance due to SFBC diversity. FER simulation performance of M-DCCH is shown in figure 5.

Allocated resource of M-HICH is reduced from existing 6RB to 3RB. Because of SFBC diversity, there is no loss in performance. Resource of M-DCCH has increased. FER simulation performance of M-HICH is depicted in figure 6.

Figure 3 shows the structure of downlink demodulation of MHN-E system, which includes data channel M-DSCH and control channels M-BCH, M-DCCH and M-HICH.

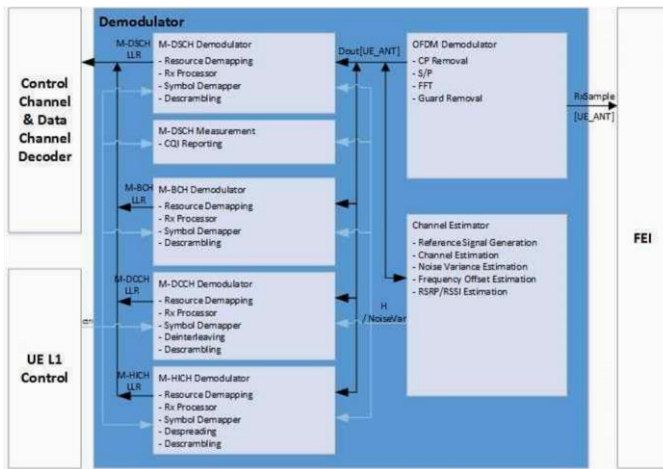


Figure 3. Structure of DL Demodulator of MHN-E system

IV. SIMULATION RESULT

From figure 4 to figure 6 show the FER (Frame Error Rate) performance simulation results of M-BCH, M-DCCH and MHICH, respectively, of the MHN-E downlink control channels. Channel model in this simulation is the Rician channel model with the K-factor values of 10 and 100. Simulation parameters are described in table I.

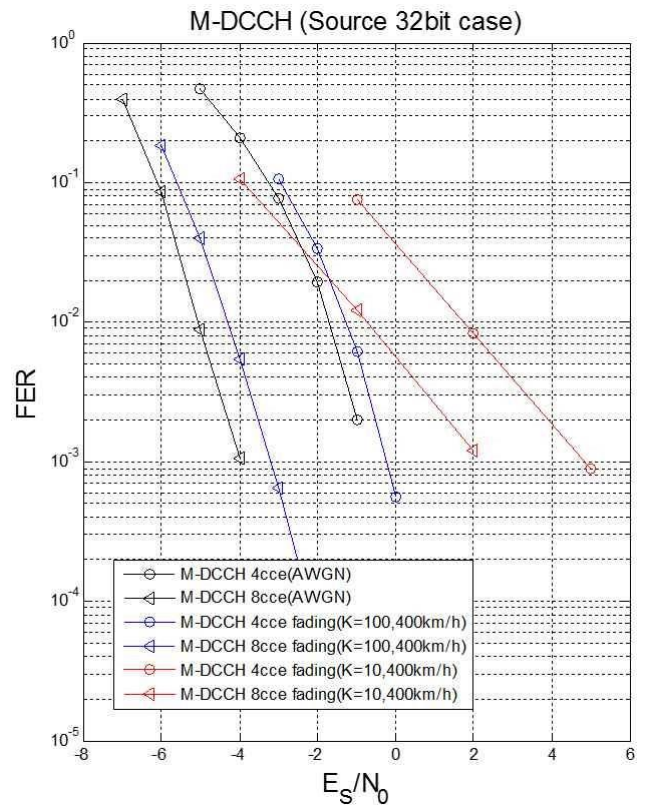


Figure 5. Performance of M-DCCH

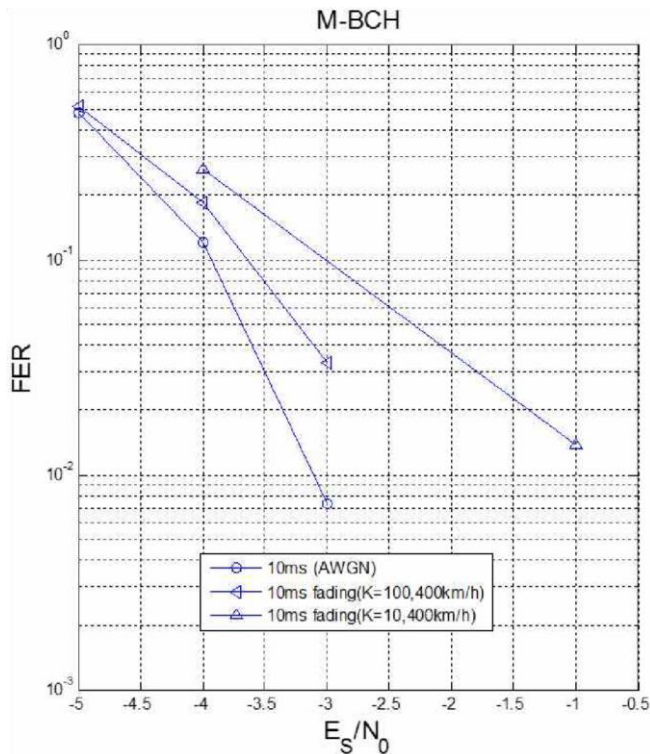


Figure 4. Performance of M-BCH

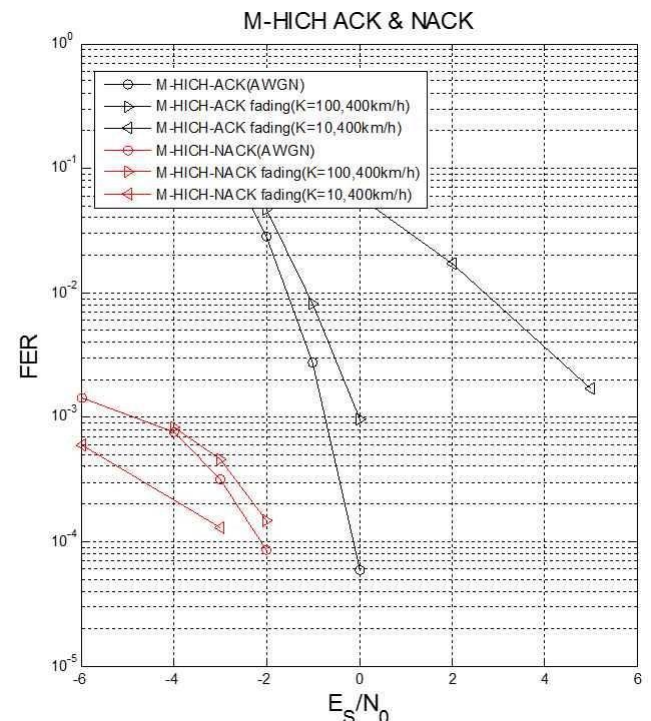


Figure 6. Performance of M-HICH

Figure 4 is the simulation result of M-BCH. We can see that the performance with K=100 is better about 1.5dB than K=10 case. Figure 5 displays the performance results of MDCCH simulation. As the number of CCEs grows, the performances are

better. In MHN-E specification, only two types of CCEs, 4 and 8 CCEs, are defined. Figure 6 displays the performance results of M-HICH simulation. As misunderstanding NACK to ACK

can cause severe fault to system, it is highly recommended that the performance of NACK case is much better than ACK case.

TABLE II. SIMULATION ASSUMPTIONS

Parameters	Values
System Bandwidth	125 MHz
Carrier frequency	27 GHz
Tx Mode	SFBC
Modulation	BPSK, QPSK
Decoder	Tail-biting Viterbi
Channel estimation	LS estimation
Delay spread	100ns
Channel Model	Rician

V. CONCLUSIONS

In this paper, we introduced the MHN-E wireless mobile backhaul system that can support up to 10Gbps downlink transmission data rate in moving group vehicle environment with millimeter wave wide band, which is especially focused on the group vehicles that are moving at high speed up to 500km/h such as an express train and a subway. We displayed the downlink control channel frame structure and explained several downlink control channels of MHN-E system.

Furthermore, we simulated and verified the performance of downlink control channels with the Rician channel model in MHN-E system.

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Dae-Soon Cho received the B.S., M.S. degrees in electronic engineering from Dongguk University and Ph.D. degrees in KAIST, Korea, in 1995, 1997, and 2014, respectively. He is working at ETRI (Electronics and Telecommunications Research Institute) as a principal member of engineering staff. His current research interests are 5G mobile and wireless communications.



Ilgyu Kim received the B.S., M.S. degrees in electrical engineering from University Of Seoul and Ph.D. degrees in KAIST, Korea, in 1993, 1995, and 2009, respectively. He is currently a team leader in Electronics and Telecommunications Research Institute. His current research interests include millimeter-wave mobile communication system.