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An Improved HARQ Mapping Mechanism in LTE-Advanced System

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Abstract

Based on the analysis of the current hybrid automatic repeat request (HARQ) mapping mechanism and the corresponding problems in LTE-Advanced system with carrier aggregation, this paper designs an improved HARQ mapping mechanism, in which an idea of semi-static mapping is introduced. The simulation results validate its effectiveness in improving system performance through the trade-off between diversity gain and overhead.

Index Terms: LTE-Advanced; carrier-aggregation; HARQ

1. Introduction

Due to high-speed development of the mobile communications technology, the amount and demand of mobile user progressively increases yearly. The reason 3GPP devotes itself to the research of 3GPP LTE (Long Term Evolution) for the evolution of 3G (Third Generation) is that Third Generation Mobile System (TGMS) can not meet the need of users completely. In order to provide faster higher-data-rate and support multi-user service, the new demand of LTE-Advanced are in the aspects of frequency, bandwidth, peak rate and compatibility [1]. The combination of carrier aggregation technology and hybrid automatic repeat request (HARQ) technology can guarantee the transmission accuracy on the condition of bandwidth addition [2]. A semi-static HARQ mapping mechanism proposed in this paper is an improved mechanism between the static mapping and variable mapping.

2. PDSCH and PUSCH mapping

In the past RAN1#55bis meeting, it has been passed that the mapping relation of MAC-to-PHY is as below

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2.1. transport block

Each dispatching of the component carrier has a transport block (no consideration of spatial multiplexing) and a separate HARQ UE (user equipment).

2.2. A UE can receive multi-component-carrier simultaneously.

On the consideration of the correspondence relation between HARQ process and component carrier, at present, the main mapping of HARQ process and PDSCH/PUSCH (physical downlink shared channel / physical uplink shared channel) are as below.

1) Static mapping.

HARQ process has a one-to-one correspondence with DL/UL(downlink/uplink)component carrier [3-4]. In this case, the corresponding content of PDSCH and HARQ process are in accordance with Rel8 LTE system. Therefore, each component carrier of downlink needs three bits to indicate HARQ process ID, the reason for selecting three bits is that the number of HARQ process is eight. The first transmission is in the CCB (component carrier B) which corresponds to (B, 4) in the eight HARQ process (B, 0 ~ B, 7), as is shown in fig 1. If the checkout fails, retransmission occurs, in the static model, retransmission will select CC B and correspond to HARQ process (B, 4) at the same time.

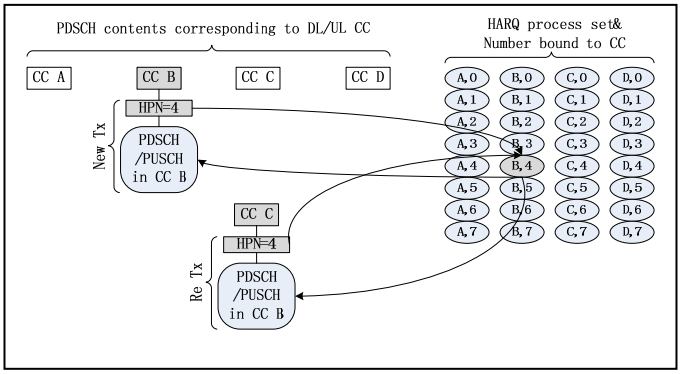

Fig.1 HARQ process setting of static mapping

2) Variable mapping.

The process setting of HARQ and DL/UL component carrier can be mapped limberly. It allows retransmission among component carriers, which gain much higher flexible dispatching gain of diversity gain and component carrier [5-6]. Nevertheless, each component carrier requires additional [1bn] bits for indicating the corresponding component carrier sequence number of HARQ. Therefore, it costs more. In the case of variable mapping model, if the first transportation occurs in the CCB (component carrier B); it corresponds to HARQ process (B, 4). If the checkout fails, the retransmission occurs; it requires calculating the optimal component carrier. By comparing the factors that different channel quality of the component carriers, dispatching the retransmission to a new component carrier, such as CC A or CC C, the corresponding HARQ process is still (B, 4).

In semi-static variable mapping mechanism of HARQ process, the data of three times retransmission selects a component carrier that apart from itself in turns. After the predefining selection mode, it needs no additional indicating bits and saves the cost, also obtains certain gain. In figure 2, the first transmission is CC B, corresponding to process (B, 4) of HARQ. In the case of retransmission, the sequence of retransmission about component carrier in the first, the second and the third time is CC A, CC C and CC D, namely

dispatching to different component carrier sequentially, and every time the corresponding HARQ process is still (B, 4). Different CC (component carrier) brings certain diversity gain but sequential selection needs no indicating bits, just needs previous setting. In addition, CC selecting mode can be carried out according to other principles but not sequential selection, it requires further research of better sequential principle.

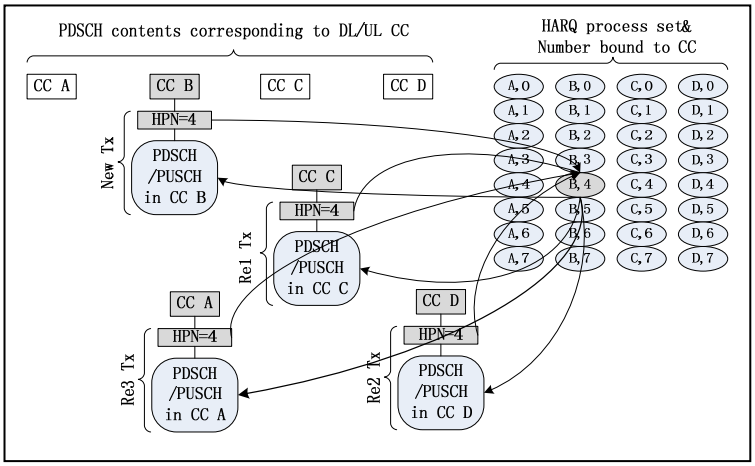

Fig.2 HARQ process setting of semi-static mapping

3. Simulation analysis

Simulation conditions are as shown in table 1. This paper gives a semi-static simulation of mapping mechanism of HARQ performance. The main consideration is block error rate (BLER) and the curve of retransmission number. Initial data sent through the channel has Es/No (dB) and the variation rage is [-1 4]. At each retransmission error, the mechanism changes the load carrier of data in accordance with the serial number sequence of component carrier, rather than the variable mapping mechanism that calculates the best quality of channel of the component carrier as load carrier. Because the fluctuation of channel quality, the simulation selects a mechanism that plus the original Signal-to-Noise Ratio (SNR) with a random sequence, simulates channel quality that chose from other sequence of component carriers. Meanwhile, on the condition of actual situation, the random number should adapt to the certain conditions. Firstly, it fluctuates around the original SNR; Secondly, fluctuating range generally is not great; finally, due to the cases that changing of component carrier appears in transmission error, the initial component carrier quality is worse, and then the probability of other component carrier better than the initial is not great. Therefore, five kinds of circumstances are given in the table 2 as below.

Figure 3 is the improved scheme BLER curve. In figure 3, the component carrier is changed by retransmission. From Case2 to Case4, bit error rate (BER) drops faster and earlier than Case0 significantly. Although Case1 is not fast than Case0 partly, but in low SNR conditions, Case1 is superior to Case0, and considering the practical situation, SNR fluctuating range would tend to Case2 and Case4, namely, downward fluctuation is little but upward fluctuation is great. Therefore, the BER performance of improved scheme is better than the initial Case0 scheme. Figure 4 is the number of average retransmission curve; also, we can conclude that the number of improved average retransmission reduced substantially. Therefore, this paper proposes the semi-static HARQ scheme can gain better performance without any increase of overhead significantly.

Table.1 Simulation conditons

Simulation conditions	
Modulation	QPSK
Channel coding	1/3 TURBO
Channel model	AWGN
Rate / Code rate	1 / 2
Decoding algorithm	LOG-MAP
SNR range / dB	[-1 , 4]
Channel estimation	Ideal channel
Maximum retransmission	3 times
Retransmission date integration model	maximum

Table.2 SNR fluctuation range of retransmitted component carrier

SNR fluctuation range of retransmitted component carrier					
Cases	0	1	2	3	4
Range Es/No/dB	static	[-1,3]	[-1,4]	[-2,4]	[-2,5]

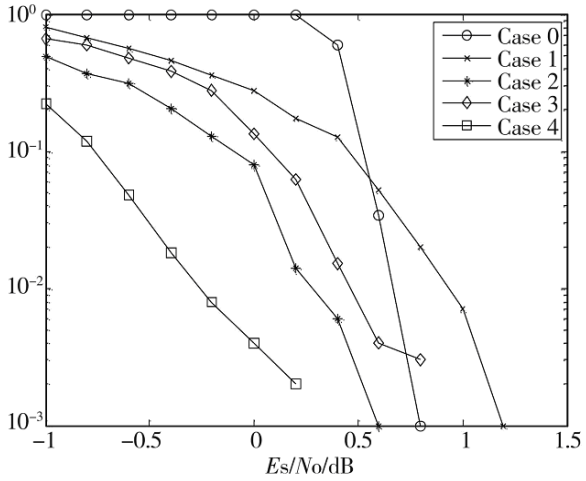

Fig.3 BLER curve in the improved scheme

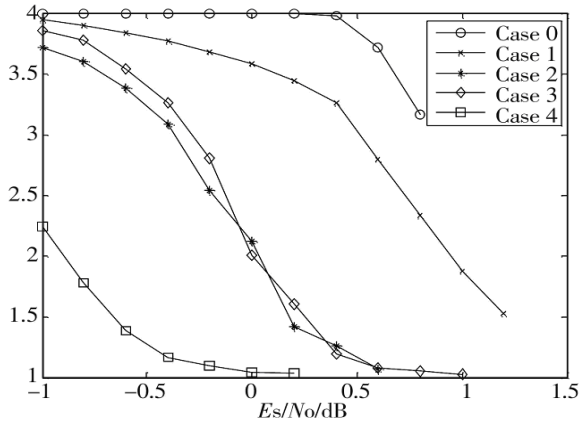

Fig.4 Average number of retransmission in the improved scheme

4. Concluding remarks

Based on the introduction of the carrier aggregation and the HARQ technology in LTE-A system, this paper proposes a semi-static mapping mechanism of HARQ, which between diversity gain and overhead, that is integration and improvement of the static mapping and the variable mapping. Through the simulation analysis, this mechanism provides better performance than static mapping, requires no additional indicating bits for similar variable mapping and it meets the requirement of practical application.

In addition, semi-static mapping mechanism requires the setting of mapping model previously, the simplest method is selecting component carrier in sequence, and other schemes will be adopted if no additional overhead in return.

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