http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet

Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (17): 4180-4183, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.4180.4183

Research of Encoding Algorithm Efficiency in 4G Communication

Dai Nina and Cai Li
Signal and Information Processing Key Lab, Chongqing Three Gorges University,
Chongqing, 404000, China

Abstract: The efficient method how to calculate the physical layer communication rate matching in LTE communication system is proposed. The algorithm is based on the study of Turbo code transmission channel. The main process is that after treatments of multiple modules such as bits collection, selection, transmission, block interleaver and block cascade, the rates of streams are matched. The key algorithm efficiency is analyzed and its performance is better than other codings. The algorithm is proved to be efficient and reliable to achieve the desired objective of high-speed and stable transmission of data in physical layer.

Key words: LTE, bit collection, block interleaver, rate matching

INTRODUCTION

LTE (Long Term Evolution) is usually called the technology of 3.9 generation. Comparing with GSM, the second generation communication technology, LTE has advent-ages of shorter waiting time, higher user data rate, greater system capacity, lower operating costs caused by coverage improvement and many others. OFDM (Orthogonal Frequency Division Multiplexing)/FDMA (Frequency Division Multiple Access) is the key communication encode algorithm of LTE technology.

The physical layer technology is a key foundation of the wireless communication system. In the LTE system, the downlink of physical layer is using OFDMA (Orthogonal Frequency Division Multiple Access) and the uplink is using SC-FDMA (Signal Carrier Frequency Division Multiple Access) for data transmission (Wang *et al*., 2012). Different ways have different transmission rates, so the communication rate matching becomes the focus of the study.

This article describes a calculation method based on the physical layer of the communication rate matching in the LTE communication system.

RATE MATCHING

Needs analysis: In LTE hierarchical structure model, the physical layer technology is the key to improve the performance of the system. The physical layer parameters directly affect the merits of delay, the data transfer rate, the system capacity, the coverage and the opera-ting costs. Physical layer process of the LTE system mainly includes a synchronization process in the physical layer, the power control process, a random access process, a related process for the physical downlink shared channel, a related process for the physical uplink shared channel and a physical shared control channel process.

Therefore, the essence of the communi-cation rate matching in the physical layer is to ensure that the amount of data of the transport channel and the physical channel can adapt each other. The basic principle of rate match-ing is that when the amount of data of the transport channel is more than that carried by the physical channel, the system performs a punch operation; on the contrary, it operates repeatedly.

Basic algorithm: If the rate of the transmission channel coded Turbo by is matched in units of blocks, the basic constructed algorithm process is as follows in Fig. 1. First, Interleave the three information bit streams (d_k (0), d_k (1) and d_k (2)). Then do the bit collection. At last, generate the circular buffer.

In the Fig. 1, e_k is the bit sequence used for transmission. The bit stream d_k (0) is interleaved according to the sub-block interleaver to get the output sequence $v_0(0), v_1(0), v_2(0), \ldots, v_{k_\Pi-1}(0)$. The bit stream d_k (1) is interleaved according to the sub-block interleaver to get the output sequence $v_0(1), v_1(1), v_2(1), \ldots, v_{k_\Pi-1}(1)$. The bit stream is interleaved according to the sub-block interleaver to get the output sequence $v_0(2), v_1(2), v_2(2), \ldots, v_{k_\Pi-1}(2)$ (Elnashar and El-Saidny, 2013).

MATCHING INSTANCES

Generating transmission data: If the transmission data in LTE physical layer is the bit sequence e_k, the method of calculating the rate matching sequence e_k is as follows:

Corresponding Author: Dai Nina, Signal and Information Processing Key Lab, Chongqing Three Gorges University, 404000, Chongqing, China

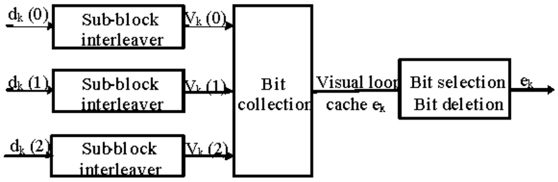

Fig.1: System sub-module

```
Set k = 0, j = 0.
While {k<E}
    If w_{(k0+j) mod Ncb} ≠ <NULL>
        e_k = w_{(k0+j) mod Ncb}
        k = k +1
    End If
j = j +1
End while
```

In the foregoing codes, N_{cb} represents the bit length of the r-th code block cache. And its formula of calculation is:

$$N_{cb} = \min\left(\left\lfloor \frac{N_{IR}}{C} \right\rfloor, K_w\right) \tag{1}$$

The Circular buffer with the length $K_w = 3K_\Pi$, corresponding to the r-th code block, is generated as follows:

$$\begin{aligned} w_k &= v_k(0) \quad \text{for } k = 0,\ldots,K_\Pi - 1 \\ w_{K_\Pi+2k} &= v_k(1) \quad \text{for } k = 0,\ldots,K_\Pi - 1 \\ w_{K_\Pi+2k+1} &= v_k(2) \quad \text{for } k = 0,\ldots,K_\Pi - 1 \end{aligned} \tag{2}$$

Sub-block interleaver: The bit stream of sub-block interleaver is d_0 (i), d_1 (I), d_2 (I), ..., d_{D-1} (i). D is the number of the bits. The output bit sequence from the sub-block interleaver is got in the following steps.

- If the number of columns of the matrix $C^{CC}_{subblock} = 32$, the columns of the matrix is sequentially numbered 0, 1, 2,…, $C^{CC}_{subblock} - 1$ from left to right.
- To determine the number of rows of the matrix, $R^{CC}_{subblock}$, which is the smallest integer satisfying the following formula:

$$D \le \left(R^{CC}_{subblock} \times C^{CC}_{subblock}\right) \tag{3}$$

The numbers of the rows of the matrix from the top to bottom are 0, 1, 2, …, $C^{CC}_{subblock} - 1$.

- If $\left(R^{CC}_{subblock} \times C^{CC}_{subblock}\right) > D$, add $N_D = \left(R^{CC}_{subblock} \times C^{CC}_{subblock} - D\right)$ visual bits in the head to make, $y_k = < NULL >$ (k = 0, 1,…, ND–1). Then $y_{N_D+k} = d_k(i)$ (k = 0, 1,…, D-1). Write the bit sequence y_k into the matrix:

Table 1: Column displacement mode table of the sub-block interleaver

Column	Column displacement mode
$C^{CC}_{subblock}$	$< P(0), P(1), \ldots, P(C^{CC}_{subblock} - 1) >$
32	<1, 17, 9, 25, 5, 21, 13, 29, 3, 19,11,27, 7, 23, 15, 31, 0, 16, 8, 24, 4, 20,12, 28, 2, 18, 10, 26, 6, 22, 14, 30>

$$\left(R^{TC}_{subblock} \times C^{TC}_{subblock}\right)$$

row by row from row 0 column 0. the final matrix is in the following formula:

$$\begin{bmatrix} y_0 & \cdots & y_{C^{CC}_{subblock}-1} \\ y_{C^{CC}_{subblock}} & \cdots & y_{2C^{CC}_{subblock}-1} \\ \vdots & \ddots & \vdots \\ y_{(R^{CC}_{subblock}-1)\times C^{CC}_{subblock}} & \cdots & y_{(R^{CC}_{subblock}\times C^{CC}_{subblock}-1)} \end{bmatrix} \tag{4}$$

- To establish column displacement mode table of the sub-block interleaver (Scaglione *et al*., 2002):

The matrix column replacement is done with fixed mode in the above table. The replacement formula is:

$$\langle P(j) \rangle_{j \in \{0,1,\ldots,C^{CC}_{subblock}-1\}}$$

in which the p (j) stands for the original position of the j-th changed column. $\left(R^{TC}_{subblock} \times C^{TC}_{subblock}\right)$ dimensional matrix which has finished the column replacement is as follows.

$$\begin{bmatrix} y_{P(0)} & \cdots & y_{P(C^{CC}_{subblock}-1)} \\ y_{P(0)+C^{CC}_{subblock}} & \cdots & y_{P(C^{CC}_{subblock}-1)+C^{CC}_{subblock}} \\ \vdots & \ddots & \vdots \\ y_{P(0)+(R^{CC}_{subblock}-1)\times C^{CC}_{subblock}} & \cdots & y_{P(C^{CC}_{subblock}-1)+(R^{CC}_{subblock}-1)\times C^{CC}_{subblock}} \end{bmatrix} \tag{5}$$

Outputs of the sub-block interleaver are read from the changed $\left(R^{TC}_{subblock} \times C^{TC}_{subblock}\right)$ dimensional matrix column by column. Thus, the output bit sequence is $v_0(0), v_1(0), v_2(0), \ldots, v_{k_\Pi-1}(0)$ in which, v_0 (i) is the y_p (0) in the matrix above , v_1 (i) is $y_{P(0)+C^{CC}_{subblock}}$ and:

$$K_\Pi = \left(R^{TC}_{subblock} \times C^{TC}_{subblock}\right)$$

Bit collection, selection and transmission: The number of the blocks N_{IR} is calculated by the step 1 above in the formula below:

$$N_{IR} = \left\lfloor \frac{N_{soft}}{K_{MIMO} \cdot \min\left(M_{DL\_HARQ}, M_{limit}\right)} \right\rfloor \tag{6}$$

N_{IR} is the total number of the soft channel.

If the UE is configured in transmission mode 3, transmission mode 4 or transmission mode 8, K_{MIMO} is the value of 2 when the PDSCH is accepted. In other cases, the value is taken as 1 (Abeta, 2010). M_{DL_HARQ} is the maximum number of processes in the downlink HARQ. M_{limit} is valued 8 constantly.

E is the length of the output sequence from the rate matching in the r-th block. rv_{idx} is the version number of the transmission (rv_{idx} = 0, 1, 2 , 3). The output sequence of the rate matching is wrote as e_k, k = 0, 1, ..., E-1.

G indicates the total available number of bits of a transport block.

In the formula $G' = G/(N_L \cdot Q_m)$, Q_m values ??2, 4, 6 respectively in the different modulation method QPSK, 16QAM, 64QAM.

When the transport block is mapped to a single-layer transfer layer, the value of N_L is 1. But when it is mapped to tow or four layers transfer layer, the value of N_L is 2 (Mohammad and Wafaa, 2012).

In the formula γ, G' mod C, C is the number of block which is calculated by step 2. Thus the length E is got from the following codes:

If r≤C-γ-1
set $E = N_L \cdot Q_m \cdot \lfloor G'/C \rfloor$
else
set $E = N_L \cdot Q_m \cdot \lceil G'/C \rceil$
End If

The symbol k_0 is defined as follows and $R^{TC}_{subblock}$ is the row of the matrix:

$$k_0 = R^{TC}_{subblock} \cdot \left(2 \cdot \left\lceil \frac{N_{cb}}{8R^{TC}_{subblock}} \right\rceil \cdot rv_{idx} + 2 \right) \quad (7)$$

SIMULATION AND ANALIYSIS

Simulation result: The bit sequence e_k in the following section is the transmission data in the physical layer. The transmission unit is a block and the value of SNR is in the normal range from 8 to 10 dB. Enough results are got from the simulation of rate matching environment of the transmission channel coded by Turbo in Matlab 7.0.

Result analyzing: It is got from the Fig. 2 that in the normal SNR communication environment and using the matching algorithm in the following section, the system can complete the matching demand through punching adjustment when the data from the transmission channel is more than the data which the physical channel can load. But when it is less than that, the system completes the need by repeating adjustment.

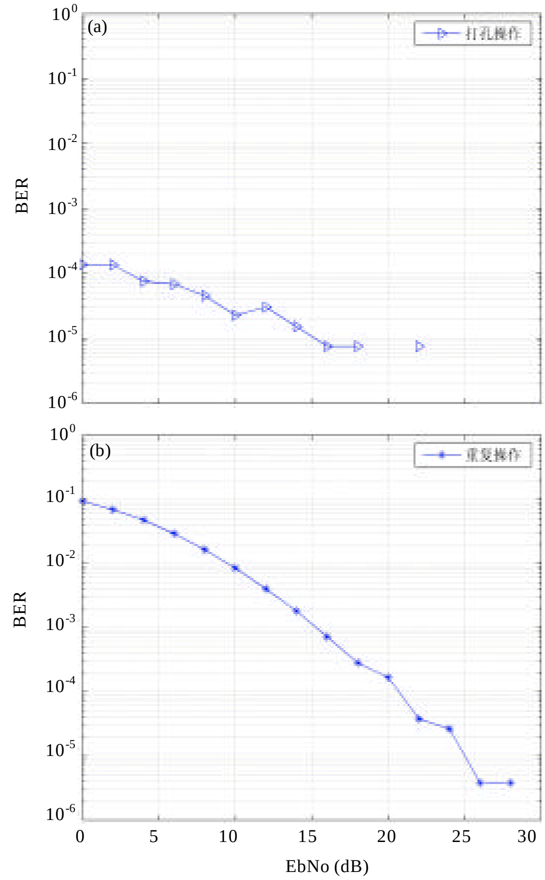

Fig. 2(a-b): Simulation result, (a) Punching operation and (b) Repeating operation

Above all, both punching and repeating operations can keep the BER lower than 20 percent. The matching algorithm in following section can achieve the desired goal.

CONCLUSION

This study describes the rate matching algorithm of the LTE physical layer based on the needs analysis. The simulation result shows that the matching algorithm is effective and has certain guiding significance and application value for assessment of LTE standard.

REFERENCES

Abeta, S., 2010. Toward LTE commercial lau-nch and future plan for LTE enhance-ments (LTE-Advanced). Proceedings of the International Conference on Communication Systems, Novemnber 17-19, 2010, Singapor, pp: 146-150.

Elnashar, A. and M.A. El-Saidny, 2013. Looking at LTE in practice: A performance analysis of the LTE system based on field test results. Vehicular Technol. Magazine, 8: 81-92.

Mohammad, A.Q.A. and A.H. Wafaa, 2012. A study on pre-4G (LTE and WiMAX) protocols towards 4G-ITU requirements. Int. J. Adv. Comput. Technol., 4: 71-84.

Scaglione, A., P. Stoica, S. Barbarossa, G.B. Giannakis and H. Sampath, 2002. Optimal designs for space-time linear precoders and decoders. IEEE Trans. Signal Proces., 50: 1051-1064.

Wang, S., L.H. Liu and Z.G. Wen, 2012. High speed QPP generator with optimized parallel architecture for 4G LTE-A system. Int. J. Adv. Comput. Technol., 4: 355-364.