ITC-CSCC 2011, June 19-22, 2011, Gyeongju, Korea

Improvement of Channel Estimation for 3.9G LTE Downlink

Akio CHIMURA†, Tomohisa WADA††
The Graduate School of Engineering and Science, University of the Ryukyus
{chimura†, wada††}@lsi.ie.u-ryukyu.ac.jp

Abstract

LTE (Long Term Evolution) is a standard of wireless mobile communication standard developed by 3GPP. It aims at high speed and large capacity communication but there is a possibility that commutation quality is degraded by fading environment. Channel estimation is one of the important technologies to enable high speed and large capacity communication in fading environment. Therefore, this paper proposes a channel estimation algorithm for LTE downlink and evaluates its performance by computer simulation. Simulation results shows that proposed algorithm reduces SNR in approximately 1.4dB at SISO channel $\mathrm{BER} = 10^{-2}$.

Keywords:*LTE, Downlink, Channel estimation*

1 Introduction

Recently, there is a need for standardized mobilephone networks in the world society. In the field of mobilephone communication, the transition to LTE (Long Term Evolution) is being promoted all over the world. It is necessary to reduce the bit error rate in the channel for high-speed communication. LTE is a network technology, also called 3.9 generation. It is the generation used to smoothly shift from the 3rd generation to the 4th generation.

Channel estimation is one of the important technologies to enable high speed and large capacity communication in fading environment. In this paper, LTE downlink channel estimation improvement algorithm is proposed.

2 LTE System

Table 1 summarizes LTE system parameters. There are seven system bandwidths such as 1.4/3/5/10/15/20MHz. Tone spacing of OFDMA subcarriers is typically 15KHz. Then OFDMA Effective symbol length is 1/15KHz = 66.66..us.

Figure 1 shows the frame structure of LTE. One frame length is 10ms and it is divided into ten 1ms subframes. The subframes are further divided into 2 slots. Each slot length is 0.5ms each. Resource Block (RB) is defined as a block of 180KHz bandwidth and 0.5ms time slot.

Table 1: LTE System Parameter

System Bandwidth (MHz)		1.4	3	5	10	15	20
Effective Bandwidth (MHz)		1.08	2.7	4.5	9.0	13.5	18.0
Guard Bandwidth (MHz)		0.32	0.3	0.5	1.0	1.5	2.0
Subframe(ms)		1.0					
Tone Spacing		15kHz(7.5kHz in case Extended CP(33.3μs))					
Sampling Rate (MHz)		1.92	3.84	7.68	15.36	23.04	30.72
FFT size		128	256	512	1024	1536	2048
Subcarrier Number		72	180	300	600	900	1200
CP Length (μs)	Normal	4.69×6, 5.12×1					
	Extended	16.6×6					
		33.3×3(DL only)					

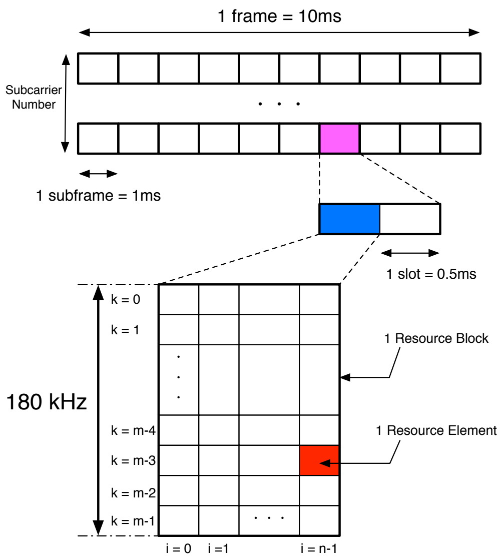

Figure 1: Frame Structure

3 Reference Signal

Figure 2 shows the data allocation method of the downlink LTE signal of 600 subcarriers and 14 OFDMA symbols. Each small rectangle block is corresponding to one subcarrier of one OFDMA symbol, which carries one complex value. The white blocks are data signals and the dark signals are Reference Signals (RSs).

RSs are the QPSK value which made by M-sequence pseudorandom numbers. The initial values of M-sequence are the system parameters such as Subcarrier Number, cell ID or CP type. Therefore base station and user equipment can make these RSs, and user equipment use RSs for channel estimation.

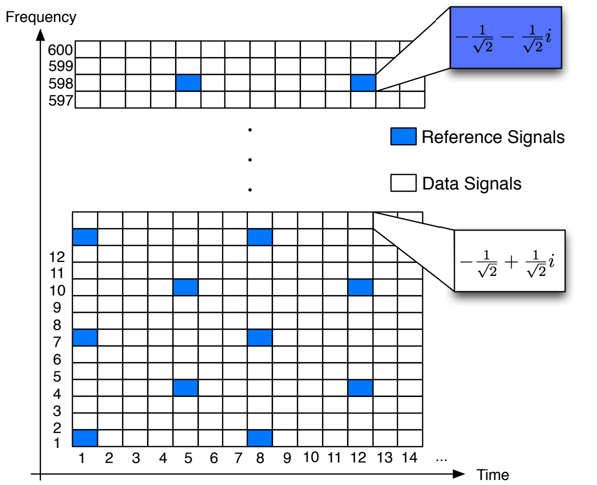

Figure 2: Reference Signal arrangement(Subcarrier Number:600, Normal CP)

4 Channel

Arranged OFDMA symbols are converted with IFFT. CP is Cyclic Prefix, as you know Guard interval.

When the user equipment receive the wave and do FFT, the OFDMA symbols are affected by noise and multipath. Therefore channel estimation is must for the OFMDA symbols.

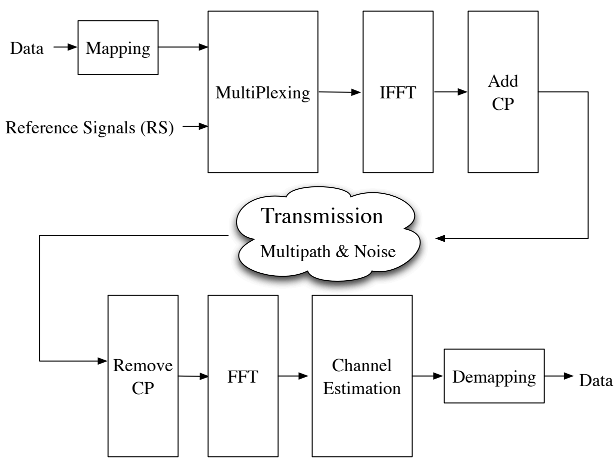

Figure 3: Flow of LTE SISO channel estimation

5 Conventional 2D Channel Estimation

Since consecutive two slots of RBs are assigned to each user, Channel Estimation has to be performed in one subframe. At the RS point, Channel Transfer Function (CTF) value can be calculated simply by dividing received RS value by the transmit RS value. Figure 4-5 shows how to obtain whole Channel Transfer Function. There are two-stage processes. In the 1st stage, signals are either interpolated or copied on time axis (Figure 4). In the 2nd stage, frequency axis interpolation is performed to get whole CTF (Figure 5).

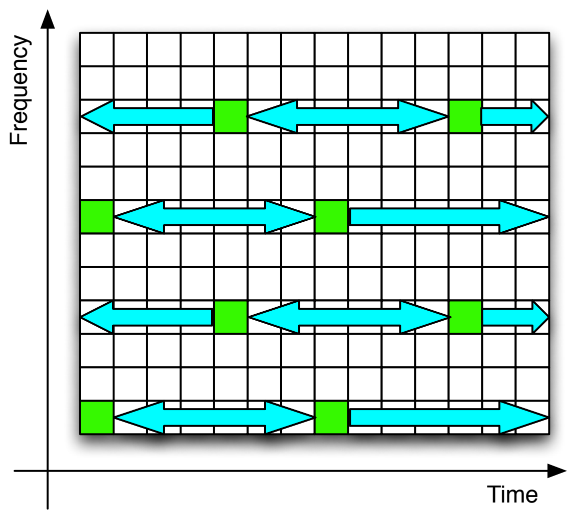

Figure 4: Time axis interpolation and copy

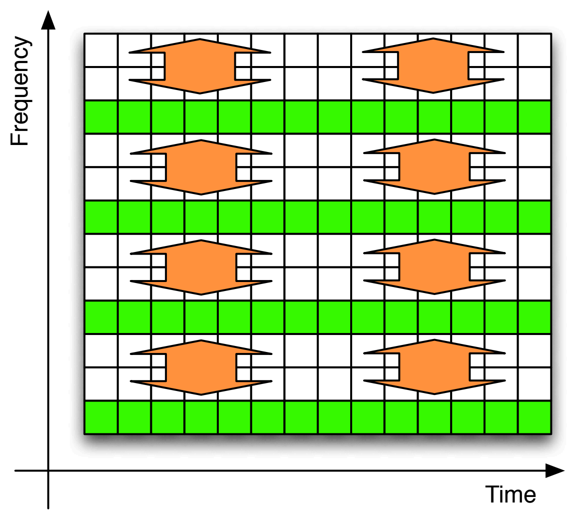

Figure 5: Frequency axis interpolation

6 Proposed Noise Reduction Method

Figure 6 shows the flow of proposed method. The noise reduction filter is inserted between the time axis interpolation and frequency axis interpolation. By assuming the maximum delay spread is smaller than CP length, CTF signal has bandwidth limited characteristics. Then complex domain band-pass filter can be used. It shows one example implementation of the noise reduction filter.

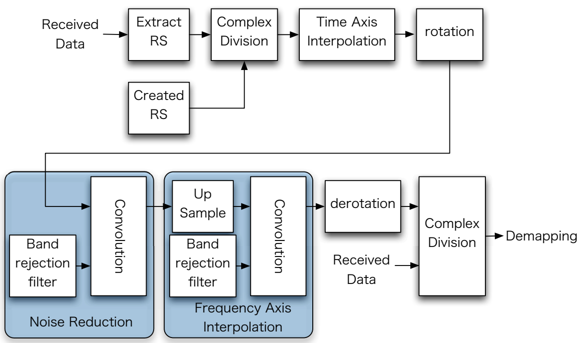

Figure 6: Flow of the Channel Estimation

Figure 7 shows the Channel Impulse Response and and noise reduction band rejection characteristics. The bar graph shows CIR (rotated). The center part of the CIR are background noise components. The noise part is removed when band rejection characteristics is applied to CIR. Therefore, the noise reduction filter is designed to reduce this part.

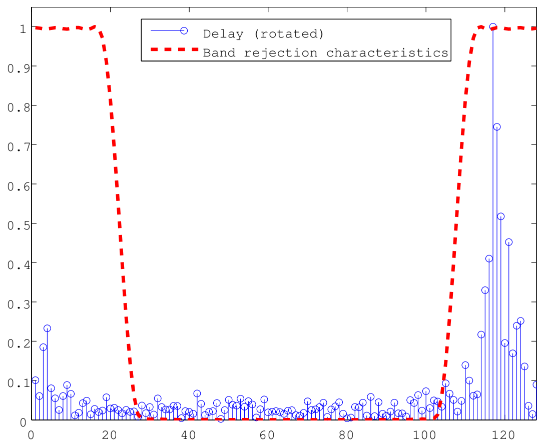

Figure 7: Rotated CIR and noise reduction band rejection characteristics

7 Simulation

7.1 Simulation Parameters

Table 2 shows the Simulation Parameter. And Table 3 is the Parameters of Extended Vehicular A Model (EVA). It is a Channel Model defined by 3GPP [1, p.134].

Table 2: Simulation Parameters

System Bandwidth	10MHz
Effective Bandwidth	9MHz
Guard Bandwidth	1MHz
Subframe	1.0ms
Tone Spacing	15kHz
Sampling Rate	15.36MHz
FFT size	1024
Subcarrier Number	600
CP Length	Normal CP $(4.69 \times 6, 5.12 \times 1)$us
Modulation	QPSK, 16QAM, 64QAM
Channel Model	Extended Vehicular A model (EVA)
Noise	Additive White Gaussian Noise (AWGN)
Maximum Doppler frequency	70Hz

Table 3: EVA Parameters

Excess tap delay(ns)	Relative power(dB)
0	0.0
30	-1.5
150	-1.4
310	-3.6
370	-0.6
710	-9.1
1090	-7.0
1730	-12.0
2510	-1.7

7.2 Simulation result

A new channel estimation algorithm for LTE downlink is proposed. Figure 8-10 show that proposed algorithm reduces SNR.

Figure 8 shows a result in QPSK, and improvement of 1.4dB is seen.

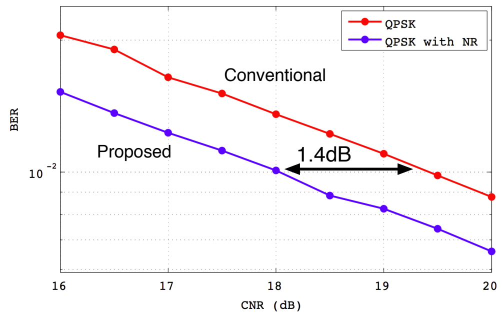

Figure 8: Simulation result (QPSK)

Figure 9 shows a result in 16QAM, and improvement of 1.0dB is seen.

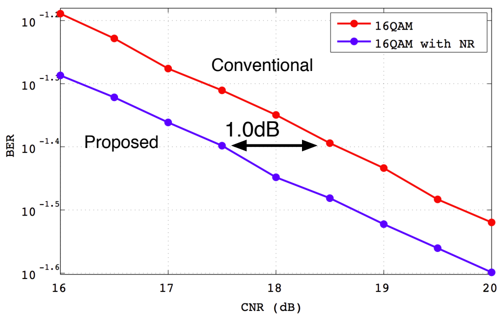

Figure 9: Simulation result (16QAM)

Figure 10 shows a result in 64QAM, and improvement of 0.9dB is seen.

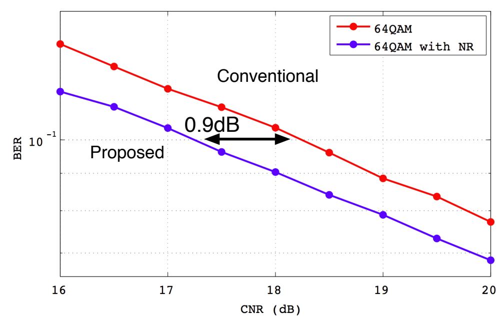

Figure 10: Simulation result (64QAM)

7.3 Conclusion

In Simulated results of noisy and multiipath-full model, error rates were improved. It shows that the proposed algorithm reduces the noise affect. The noise reduction filter was used to improve the accuracy of the channel estimation by the DownLink of LTE.

This algorithm is very simple and easy to incorporate.

The proposed method is applicable not only SISO LTE down link but also MIMO LTE down link.

References

[1] 3GPP TS 36.101 v8.8.0 (2009-12) - User Equipment (UE) radio transmission and reception

[2] LTE The UMTS Long Term Evolution - Stefania Sesia, Issam Toufik, Matthew Baker