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An Adaptive CQI Feedback Algorithm Based on SINR

Peng Daqin[1], Yang Caimin[2] and Qiu Congcong[3]

[1]*Male, master, senior engineer,*
Chongqing University of Posts and Telecommunications
[2]*Female, master degree candidate,*
Chongqing University of Posts and Telecommunications
[3]*Male, master degree candidate,*
Chongqing University of Posts and Telecommunications
[1]*E-mail: 1343936433@qq.com*
[2]*E-mail:18580398218@163.com*
[3]*E-mail: 1030825963@qq.com*

Abstract

In order to increase the stability and accuracy of Channel Quality Indication (CQI) feedback and improve the performance of the system and the transmission rate of user equipment (UE) without increasing system bandwidth in LTE-Advanced system, this paper proposes an improved adaptive CQI feedback algorithm. In this algorithm, the initial value of CQI is estimated by using the smoothing value of the signal and interference plus noise ratio (SINR), and then the value of CQI feedback is corrected by the error block rate (BLER). Finally, the algorithm is simulated so as to verify the feasibility and effectiveness of this algorithm by using MATLAB in the channel environment such as EPA5 and EVA5, and it is showed in simulation results that this algorithm can achieve good performance gain.

Keywords*: LTE-A system; SINR; CQI; BLER; adaptive feedback*

1. Introduction

With the higher and higher demands for communication services of the quality of data and transfer rate on the quality of data and transfer rate, The Link adaptation technology can improve the spectral efficiency and transmission rate without increasing the bandwidth of the system, thus becoming one of the key technologies of LTE-A system [1]. In the LTE-A system downlink data transmission process, the base station selects the corresponding Modulation and Coding Scheme (MCS) according to the CQI value fed back by the user equipment [2-3]. LTE-A system supports two forms of CQI reporting: periodic CQI reporting and aperiodic CQI reporting. The periodic CQI reporting often uses the PUCCH channel, and the aperiodic CQI reporting often uses the PUSCH channel. However, if the UE is on a sub-frame in which periodic CQI is transmitted and is scheduled to transmit data at the same time, periodic CQI reporting will be reported using the Physical Uplink Shared Channel (PUSCH). When a periodic CQI and an aperiodic CQI are reported simultaneously in the same sub-frame, only the aperiodic CQI is reported. There are three types of CQI reporting: wideband CQI, sub-band CQI for upper layer configuration and sub-band CQI for UE. Which the wideband CQI aimed at the CQI information of the entire downlink system bandwidth, and the entire sub-band set constitutes the entire downlink system bandwidth. When the sub-band CQI for UE is aperiodic reporting, The system is fed back a CQI and also indicates the location of the M sub-bands aiming at M sub-bands selected by UE; When the sub-band CQI for UE is periodic reporting, The system selects a optimal sub-band CQI to be reported and also indicate the position of the selected optimal sub-band in the corresponding wideband

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portion; The sub-band CQI for upper layer configuration aims at each sub-band CQI in the set to feed back a CQI; In above three cases, the UE also needs to feed back a wideband CQI in the entire bandwidth.

However, only with the accurate CQI feedback, UE can get a higher transmission rate [4-5]. The references [6] proves that the delay and inaccuracy of CQI will seriously affect the efficiency of LTE / LTE-A system. In order to estimate the value of CQI, The references [7-9] propose an estimation algorithm by SNR-CQI Mapping relations to estimate the CQI value. However, this algorithm does not consider the impact of user interference on CQI. References [10-12] also propose an estimation algorithm by SNR-CQI Mapping relations to estimate the CQI value, the algorithm considers user interference, but does not take the impact of BLER into account.

As to the shortcomings of existing algorithms, this paper proposes an adaptive CQI feedback algorithm by combining SINR and BLER to estimate the CQI feedback value. The simulation results show that the obtained CQI value from the proposed algorithm can effectively achieve adaptive adjustment and the throughput of the system.

2. Improved CQI Adaptive Feedback Algorithm

In the actual system, the channel for transmitting signals is time-varying channel, the MCS and the coding rate are better than the fixed MCS to improve the performance of the system and increase the throughput of the system. Adaptive selecting the MCS and code rate are better than the fixed MCS to improve the performance of the system and increase the throughput of the system. In LTE-A system, the UE feeds back the CQI information to the base station through the PUCCH or PUSCH, and the base station automatically selects the appropriate MCS to implement the adaptive tracking link change.

2.1. The Core Ideology of Algorithm

CQI is a very important parameter in LTE-A system, In LTE-A system, existing CQI reporting, channel estimation and measurement algorithms generally evaluate the channel quality by SINR. In order to improve the stability and accuracy of CQI feedback, this paper presents an improved algorithm, the core idea is as follows: First, to establish the mapping relationship between SINR and CQI by simulation. The relationship between SINR and CQI is as follows: as the CQI index increases, the corresponding SINR value is higher. Second, in order to stabilize the CQI reporting in the fast fading environment, so as to make the average throughput reach the optimum, and this regards the smoothed SINR index as the basis of the propagation environment change and the guidance of single report. Then, to pre-select reporting the CQI by SINR, and roughly confirm scope of the reporting, at last use the error block statistical information to revise the reporting CQI. The next, statistic and compute the BLER of system, to determine the adjustment strategy of CQI according to the statistical BLER result .Among in, the main ideology of CQI adjustment strategy is: by comparing the obtained BLER with the expected BLER threshold value, when the obtained BLER is less than a threshold value of the expected BLER, the CQI is adjusted upwards; when the obtained BLER is higher than a threshold value of the expected BLER, the CQI is adjusted downwards; In other cases, the CQI is not adjusted. Finally, according to the MCS changes issued by the base station and statistical calculation of the block error rate by UE to judge whether the base station responds to the CQI reported by UE, so as to confirm whether the CQI adjusted value is valid.

2.2. The Implementation Flow of Algorithm

The input estimated CQI value is based on the information of the SINR of the wideband or sub-band and the statistical block error rate. The reported CQI value is the

CQI value of the wideband and sub-band. The CQI feedback algorithm described in this paper is controlled separately for each code word, the concrete steps are as follows:

1) Obtain the report mode and transmission mode and other information based on the decoding-related information of the control channel.

2) Obtain the measured value *Sinr* of wideband/sub-band I of the current frame, then use multi-frame smoothing to calculate the average *SinrAvg[i]* of *Sinr*, and then judge whether the SINR occurs obviously negative or positive jump. When the SINR has an obviously negative jump, then set the adjusted parameter flag *AdjustCQIcleanFlag* = 1, *Sinrhold[i] = SinrAvg[i]*, and clear the CQI adjustment value *AdjustCQI*; When the SINR has an obviously positive jump, set *AdjustCQIcleanFlag* = 2, *Sinrhold[i] =SinrAvg[i]*, and clear *AdjustCQI* value; When the SINR has no obviously jump, and set *AdjustCQIcleanFlag* = 0, the values of *Sinrhold[i]* and *AdjustCQI* remain constant.

3) Determine the initial value of *CQI_index* according to the sub-band / wideband *sinrAvg [i]* obtained in the second step, the correspondence table of *CQI_index* and *SINR* in AWGN mode is shown in Table 1.

Table 1. The Correspondence Table of *CQI_index* and *SINR* in AWGN Mode

CQI_index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SINR(db)		-6	-4	-1.5	0	2	4	5.5	7.5	9.5	11	13	15	19

An example of searching *CQI_index* based on the *SinrAvg [i]*: if when the estimated *SinrAvg [i]* <= -6db, so the reported *CQI_index* value is 2; if when the estimated -6db <*SinrAvg [i]* <= -4db, so the reported *CQI_index* value is 3; in other cases, the reported *CQI_index* values are searched by analogy. It should be noted here: the corresponding relationship between *CQI_index* and *SINR* is different in different transmission modes.

4) Calculate the lower limit value *CQILimitMin*, the upper limit value *CQILimitMax*, and the corresponding sub-band identification *SubLimit* of the reported *CQI_index* according to the value of *AdjustCQIcleanFlag* obtained in the second step.

5) Then update the CQI adjustment value *AdjustCQI* according to the value of *AdjustCQIcleanFlag* obtained in the second step; the range of *AdjustCQI* is from *AdjustCQILimitMin* to *AdjustCQILimitMax*; and the values of *AdjustCQILimitMin* and *AdjustCQILimitMax* are determined by the actual test, it sets *AdjustCQILimitMin* the value of -4 and *AdjustCQILimitMax* the value of 4. If the value of *AdjustCQIcleanFlag* is not equal to 0, then *AdjustCQI* = 0; If the value of *AdjustCQIcleanFlag* is equal to 0, then calculate the value of *AdjustCQI* according to the statistical error rate information.

6) Update the value of *CQI_index* according to the initial value of *CQI_index* determined in the third step and the CQI adjustment value *AdjustCQI* calculated in the fifth step; Namely, *CQI_index* = the initial value of *CQI_index* plus *AdjustCQI*.

7) Finally, revise the upper and lower limit of *CQI_index* calculated in the sixth step according to *CQILimitMin* and *CQILimitMax* calculated in the fourth step.

The flow chart of CQI adaptive feedback is shown in Figure.1.

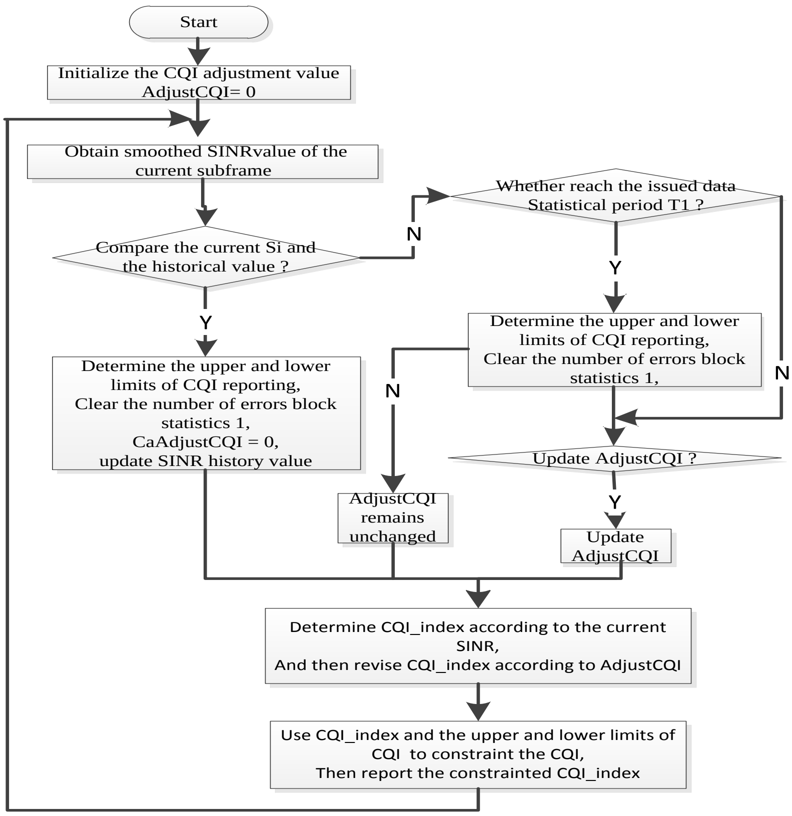

Figure 1. The Flow Chart of CQI Adaptive Feedback Algorithm

The statistical period *T1* in fig.1 is used for counting the block error rates of the CQIs, which is to calculate a lower limit value named *CQILimitMin* and an upper limit value named *CQILimitMax* of the CQI. The error block number statistics arrary1 is used to count the number of error blocks of each CQI in the statistical period *T1*.

3. The Simulation Results and Analysis

According to the above algorithm principle, using the MATLAB software for the improved adaptive CQI adaptive feedback algorithm based on SINR in channel environment EPA5 and EVA5. Compared with the fixed CQI feedback algorithm in performance gain of LTE-A system. The simulation conditions used in the simulation are shown in Table 2, and the simulation results in Figure.2 and Figure.3 below.

Table 2. The Simulation Conditions of CQI Reporting Algorithm

Antenna configuration	4x4
Channel environment	EPA5、EVA5
bandwidth	10MHZ
CFI	2
The Ratio of up and down	1
Special sub-frame configuration	4
RI	1
SINR	-10：2：30
Number of simulation iterations	200

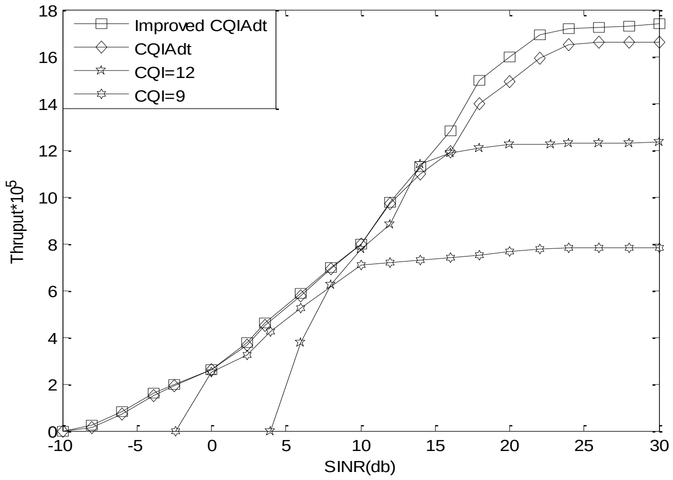

Figure 2. The Simulation Diagram of CQI Reporting Performance in EPA5 Channel

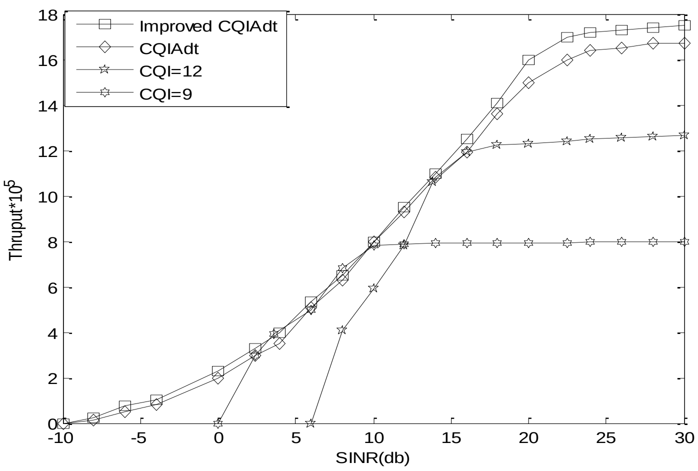

Figure 3. The Simulation Diagram of CQI Reporting Performance in EVA5 Channel

4. The End

In the LTE-A system, The CQI reporting is an essential part of the downlink data processing. In order to improve the accuracy of CQI estimation and the throughput of the system, so an improved adaptive CQI feedback algorithm is proposed in this paper. In this algorithm, not only noise and user interference are considered, but also the reported CQI is corrected by BLER. From the simulation results, we can see that the proposed algorithm improves the performance of CQI reporting and increases the throughput of the system, which is feasible and effective. In addition, the algorithm has been applied to the development of "TD-LTE-Advanced terminal baseband chip sample development", which is of great practical significance.

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