

# Improve Multi-Cell Interference Cancellation for TD-SCDMA Mobile Satellite System

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**Abstract** –an access user based interference reconstruction procedure starting from the access user with maximum peak-value power. Simulation results indicate that compared to existing IC methods, the proposed algorithm expresses not only higher This paper proposes a novel multi-cell channel estimation algorithm based on successive interference cancellation (SIC) for Time Division Synchronization Code Division Multiple Access (TD-SCDMA) systems. Unlike existing interference cancellation (IC) schemes, where the interference reconstruction is cell based, the proposed algorithm develops estimation precision but also lower computational complexity.

**Keywords:** Successive Interference Cancellation, TD-SCDMA, Multi-cell Channel estimation,

## I. Introduction

TD-SCDMA is one of the standards for third generation (3G) cellular mobile systems [1]. Compared to other 3G CDMA systems, the main features of TD-SCDMA are the utilization of smart antennas and joint detection receiver [2]. However, both the aforementioned key technologies are highly dependent on the accuracy of channel estimation (CE) [3] [4]. Consequently, to guarantee the performance of TD-SCDMA systems, it is desirable to develop a CE algorithm with high precision and low complexity. Recently, a low cost and high accurate Steiner channel estimator according to the maximum likelihood criterion [5] is widely applied for channel estimation under the condition of single cell environment. In [7], the authors proposed an extended Steiner channel estimator, which is a simple extension of the channel estimator in [5] to the application for multi-cell environments. However, the extended Steiner estimator simply considers the inter cell multiple access interference (MAI) as noise, which results in its relatively low performance. By considering the strong inter cell MAI as useful signals, [6] proposes a multi-cell joint channel estimation (JCE) method that estimates the channel impulse responses (CIRs) for all access users jointly. Therefore, the JCE method presents excellent performance. However, the JCE method inevitably meets an inversion operation of a large dimension matrix, leading to extremely high computational complexity.

Moreover, the sum of access users for multi-cell JCE processing should not exceed a threshold. However, this constrain can be easily broken, especially when quite a few users are located in the cell boundary. The aforementioned drawbacks of JCE method, especially its extremely high complexity, block the application of JCE method in practice. This results in some research interest focusing on the investigation of multi-cell channel estimation algorithm based on inter cell interference (IIC) as in [7] and [8]. Compared to the JCE method, the method based on IIC does not consider the limits of the number of access users and expresses acceptable computational complexity. The estimator based on IIC includes several stages. In each stage, the estimator estimates, reconstructs, and cancels out MAI from the received signal, in a serial or parallel manner.

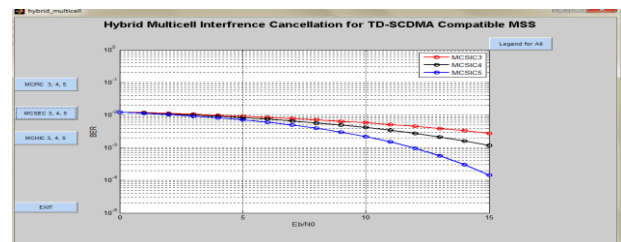


Fig.1. Multi-cell serial interference cancellation for 3,4and5 cells.

## II. Analysis

As analyzed in this paper, the channel estimation algorithm based on successive interference cancellation (SIC) [8] outperforms the one based on parallel

interference cancellation (PIC) [7] in both performance aspect and complexity aspect. However, the estimation error of some CIRs with low signal-to-noise ratio (SNR) may be very high for SIC channel estimator, leading to a large gap between the performance of SIC estimator and JCE estimator. To fill the aforementioned gap, in this paper, we propose a new channel estimation algorithm based on SIC, which can both achieve reliable channel estimation and support and users access. Different from the existing cell-based SIC channel estimation algorithm [8], which treats a cell as the interference reconstruction unit, the proposed SIC channel estimation algorithm, is access user-based method, which means the interference is reconstructed user by user starting from the access user signal with maximum received power during every iteration. Therefore, the proposed SIC algorithm shows better performance than existing ones.

### III. Received data model

A burst consists of two data In TD-SCDMA systems, data of multiple users is transmitted blocks separated by a midamble code, which is used for channel estimation. Each user in the same cell is allocated a different time-shifted version of a basic cell-specific midamble code.

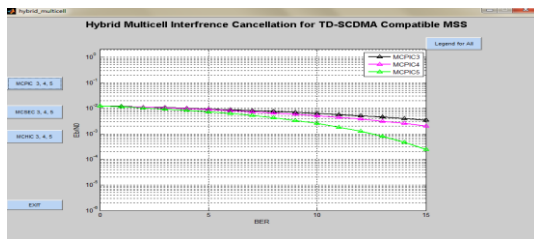


Fig.2. Multi-cell parallel interference cancellation for 3,4 and 5 cells.

As the other CDMA-based systems, both MAI and ISI cause significant degradations to the uplink performance of this system, including intra-cell interference and inter-cell interference. Joint detection [5], as one linear multi-user detection (MUD) technique [3]-[4] is widely used to eliminate the MAI and ISI within the reference cell. One common JD algorithm is the Minimum mean squared error

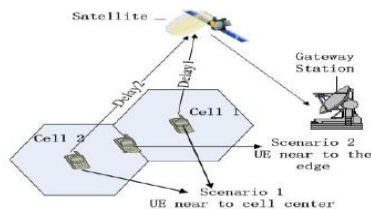


Fig.3. Uplink system

Scheme has been reported previously [7]-[8], MMSE) algorithm [6]. However, traditional single-cell joint detection (SCJD) scheme handles inter-cell interference

as white noise, which greatly limits the detection precision. To reduce the interference from the adjacent cells, one inter-cell interference cancellation (ICIC) according to the received signal in the reference which estimates and cancels the adjacent cell interference cell.

For the adjacent cell signal is much weaker than the reference cell signal, the adjacent cell data is not estimated as precious as the reference cell data, which degrades the uplink system performance. For each cell, the estimation of the same adjacent cell is repeated, which wastes resource and increases the computational complexity. With the uplink protective window technology [1], all users at different positions within the same cell synchronize with the user at the cell center (Scenario one). The transmission delay difference between two different cells can be seen as the transmission delay difference between the users at the center of the two cells. In the TD-SCDMA compatible MSS system, the sub-frame structure is in symmetric mode [9]. There are four downlink slots between the uplink slot blocks of two consecutive sub-frames in HFDD and they can be seen as the guard interval. In GEO system with 200-km cell radius, the transmission

delay difference between two adjacent cells is up to 1.35ms. For the maximum value is less than the length of two slots in TD-SCDMA system, the sub-frame can be used as the basic processing unit for the uplink data detection. The computation needed for four channel estimation algorithms under different rounds of iteration are illustrated in To keep the figure easier to read, multi-cell JCE is not shown. We remark that the complexity of the three channel estimation algorithms based on IC change linearly over the increasing round of iterations while the newly proposed CE algorithm is of the smallest slope. Therefore, when high precision is required for channel estimation, the newly proposed scheme may largely reduce the burden for computing. depict the comparison of the mean square error (MSE) and bit error rate (BER) of the five CE algorithms in two different channel environments respectively (with one round of iteration). It can be observed that, due to the amplification effect of multi-cell JCE algorithm on noise, the estimation error is higher than the other four CE algorithms when SNR is relatively low, but its estimation precision greatly increases with the increase of SNR. However, the complexity of multi-cell JCE is too high (explained in next sub-section), which is difficult to apply in practical systems.

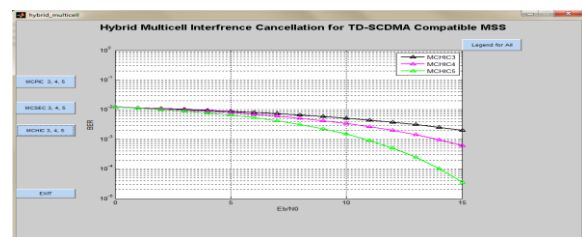


Fig.4. MCHIC for 3,4 and 5 cells

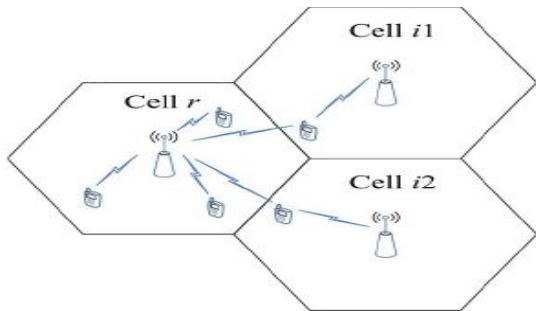


Fig.5. Interference between three cells

Take it as an optimal performance bound for reference. Apparently, among the rest IC algorithms, the proposed scheme has the lowest MSE, and it is closest to the estimation performance of multi-cell JCE when SNR is not high. Similarly, as for the effects on uplink BER of the five estimation algorithms, the conclusion is essentially analogous to the above circumstance.

#### IV. Conclusion

This paper has proposed a new access user-based SIC channel estimation algorithm for a TD-SCDMA system. Simulation results and complexity analysis have demonstrated that compared to existing SIC channel estimator, the proposed SIC estimator expresses not only better performance but also lower computational complexity. Although the JCE channel estimator is still the one with best performance so far, its extremely high complexity makes the JCE estimator impractical. Therefore, the proposed SIC channel estimator is the best one that can be implemented in practice to improve uplink performance of TD-SCDMA systems.

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