Performance Analysis of QS-CDMA Systems

Cuiran Li, Jianli Xie, and Chengshu Li

***Abstract*—**In the paper, the performance of quasi-synchronous CDMA (QS-CDMA) system, which can allow an increased timing error in synchronized access, is discussed. Average BER performance of the system is analyzed in the condition of different access timing error and different asynchronous users by simulation in AWGN channel. The results show that QS-CDMA system is shown to have great performance gain over the asynchronous system when access timing error is within a few chips and asynchronous users is tolerable. However, with access timing error increasing and asynchronous users increasing, the performance of QS-CDMA will degrade. Also, we can determine the number of tolerable asynchronous users for different access timing error by simulation figures.

***Keywords*—**Code-division multiple access, Quasi-Synchronous CDMA, Access timing error

I. Introduction

CODE-division-multiple-access (CDMA) communication systems have attractive features, such as antijam resistance, low probability of interception, resistance to multipath fading and capability of random access, which have been widely researched. The capability of random access, namely asynchronous CDMA (A-CDMA) system makes the inference of Multi-Access Interference (MAI) and Far-Near effect very serious. To solve this problem, synchronous CDMA (S-CDMA) has been proposed; in which users have access synchronously. Compared with A-CDMA, S-CDMA shows good performance as far as the perfect synchronization is fulfilled. This perfect synchronization, however, is very difficult to implement, which often occurred in the reverse link. Based on these, Quasi-Synchronous CDMA (QS-CDMA) is proposed, in which allows a certain amount of access timing error in the synchronization[1-9].

The paper analyzes the performance of QS-CDMA system in AWGN channel. The results show that the performance of QS-CDMA system is close to that of S-CDMA when access timing error is within a few chip and asynchronous users is tolerable. This paper is organized as follows. Section Ⅱ discusses the QS-sequence and evaluates the performance. Section Ⅲ give the simulation results. Conclusions are drawn in Section Ⅳ.

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II. QS-Sequence and Performance Analysis

This section deals with the performance evaluation of the QS-CDMA system in terms of BER. The performance of QS-CDMA is strongly dependent on the signature sequences[7].Let QS-sequence be defined as the spreading sequences which allow a certain amount of access timing error. To reduce multi-user interference in the presence of access timing error, cross-correlation of QS-sequences should be kept minimum within a certain chips. The set of sequences which has a large range of minimum cross-correlation and has a large family of the sequence, are optimal for QS-sequences. In this paper, the QS-sequences selected from m-sequences and Walsh-codes are discussed, and average BER in the presence of access timing error in AWGN channel is evaluated by simulation.

We first select a set of QS-sequences for the case of m-sequences. In simulation, we produce m-sequence of length 31, and every cyclic phase shift 3chips is assigned to each user, which are shown as

$$C_1 = \{PN_1, PN_2, PN_3, PN_4, \cdots PN_{31}\};$$
$$C_2 = \{PN_4, PN_5, \cdots PN_{31}, PN_1, PN_2, PN_3\};$$
$$\vdots$$
$$C_6 = \{PN_{16}, PN_{17}, \cdots PN_{31}, PN_1, PN_2, \cdots PN_{15}\}; \quad (1)$$

We then select a set of QS-sequences for the case of Walsh-codes. In simulation, we produce Walsh-codes of length 32 which is denoted as $W_i(t), i = 1,2,\cdots,32$, and choose six Walsh-codes randomly for six users.

$$C_1 = \{W_1, W_2, W_3, W_4, \cdots W_{32}\};$$
$$C_2 = \{W_3, W_4,, \cdots W_{32}, W_1, W_2\};$$
$$\vdots$$
$$C_6 = \{W_{11}, W_{12} \cdots W_{32}, W_1, \cdots, W_{10}\}; \quad (2)$$

The BER performances of QS-CDMA in the condition of different access timing error and different asynchronous users are shown in Fig.1-6. For comparisons, the performance of S-CDMA and A-CDMA is analyzed in Ref.[10]. For S-CDMA system, the ratio of signal power and noise power is written as

$$SNR_{S-CDMA} = \frac{2E_b}{N_0} \quad (3)$$

and bit-error-rate can be expressed by

$$BER_{S-CDMA} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \quad (4)$$

where

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-(y^2/2)} dy \quad (5)$$

For A-CDMA system, the ratio of signal power and noise power is given by

$$SNR_{A-CDMA} = \left[\frac{N_0}{2E_b} + \frac{K-1}{3N} \right]^{-1} \quad (6)$$

and and bit-error-rate can be obtained as

$$BER_{A-CDMA} = Q\left(\sqrt{\left[\frac{N_0}{2E_b} + \frac{K-1}{3N} \right]^{-1}} \right) \quad (7)$$

III. Simulation Results

In this section, we study the performance of the QS-CDMA system by simulating the BER vs. SNR. The BER performances for different access timing error and different asynchronous users are shown in Fig. 1-Fig. 6.

From Fig.1 and Fig.2, It is observed that the performance of QS-CDMA will degrade with access timing error increasing on the condition of one asynchronous user. We also see that the scope of tolerable access timing error for m-sequence is much larger than for Walsh code, the latter is just within 0.2chip or so.

From Fig. 3-Fig. 6, It is observed that when access timing error is constant, the performance of QS-CDMA will degrade with asynchronous user increasing. In Fig. 3 and Fig. 4, for the case of access timing error 0.2 chip, the number of tolerable asynchronous users reaches to half of the active users when m-sequence is used, and more than half of the active users when Walsh-code is used. For the case of access timing error 0.5 chip shown in Fig. 5 and Fig. 6, the number of tolerable asynchronous users is still remain half of the active users for m-sequence and no user is tolerable for Walsh-code. That is, when access timing error is small (less than 0.2 chip), Walsh-code is preferable for spreading code, whereas with access timing error increasing m-sequence is good choice.

IV. Conclusions

In this paper, we analyze the performance of QS-CDMA system in AWGN channel. The result shows that when access timing error is small (less than 0.2chip), Walsh-code is preferable for spreading code, whereas with access timing error increasing m-sequence is a good choice.

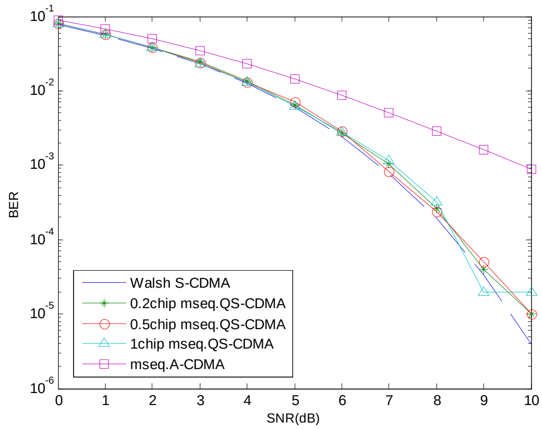

Fig. 1BER comparison of different access timing error for m-sequence (under 1asynchronous user)

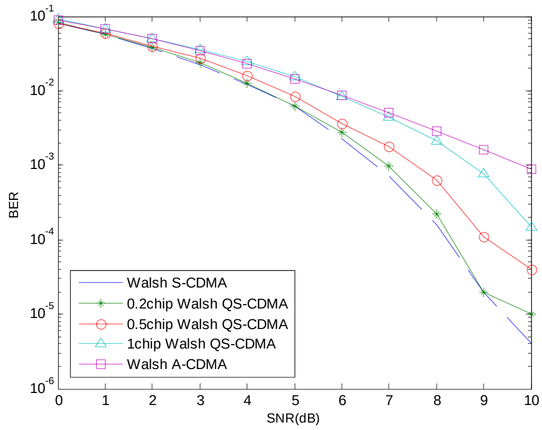

Fig. 2 BER comparison of different access timing error for Walsh code (under 1asynchronous user)

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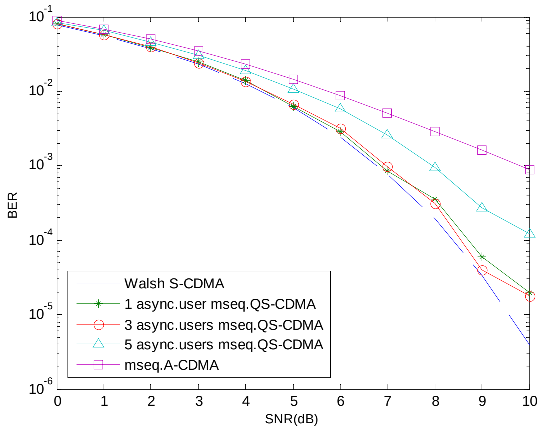

Fig. 3 BER comparison of different asynchronous users for m-sequence (within 0.2 chip access timing error)

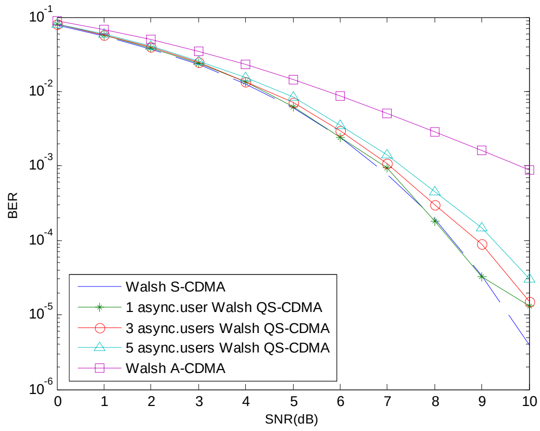

Fig. 4 BER comparison of different asynchronous users for Walsh code (within 0. 2 chip access timing error)

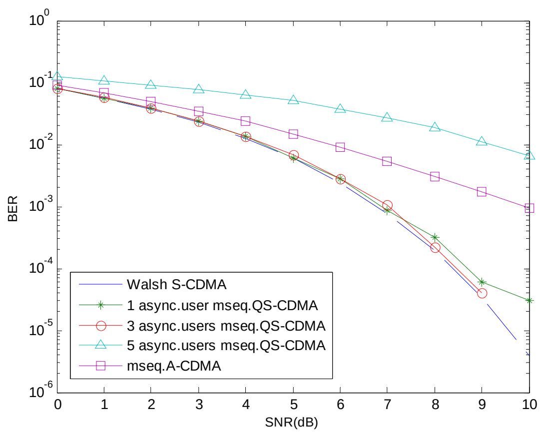

Fig. 5 BER comparison of different asynchronous users for m-sequence (within 0. 5 chip access timing error)

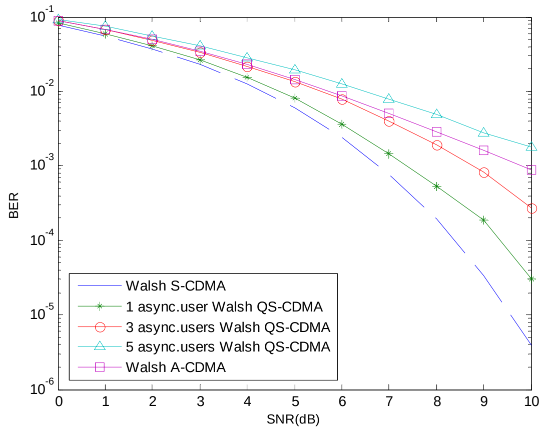

Fig. 6 BER comparison of different asynchronous users for Walsh code (within 0. 5 chip access timing error)