[7-16] Analysis of Optical CDMA System Performance with the Code Phase Alignment Approach

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Abstract: The estimation of OCDMA system performance under the condition of code phase alignment between received and locally generated code signals is done in dual homodyne correlation receiver using balanced detector. Based on the analysis of auto correlation property for prime codes, distinctive compared to the conventional CDMA codes, the developed model provides a method for interpreting the effect of code synchronization state on the false alarm probability (Pfa) and the corresponding bit error probability (Pbe). The performance influenced by the chip pulse power and noises is also examined with this model for the cases of single and multiple users.

I. Introduction

In CDMA systems, code synchronization plays a fundamental role in the system performance. This synchronization process is composed of acquisition and tracking. Code acquisition corresponds to achieving a coarse alignment between the received and the locally generated sequences, while fine alignment is demanded for the code tracking. If communications were bursty, or intermittent, and characterized by frequent periods of silence, a transmitter would emit its CDMA signal that may or may not be acquired at a receiver. In many of these cases, the detection probability and the false alarm probability are more appropriate criteria to be considered in the particular environment [1].

So far, the system performance, especially the P_{be} was extensively studied in the field of OCDMA [2], [3]. Code synchronization was disregarded or assumed to be perfect for most recently reported OCDMA works before the receiver begins to recover the transmitted data bits. The cross correlation property was just considered for the MUI analysis whereas the auto correlation property for prime codes determining the performance of code phase synchronization and ultimately that of the system was out of concern. However, because of the optical signal processing based on fiber delay lines, the auto correlation property for prime codes, and the ultra short chip pulse duration, precise code synchronization is so difficult that it could be achieved under the non-aligned condition.

In this letter, the code correlation properties are observed for the chosen prime code. The influence of the code phase alignment condition in its synchronizing process on system performance is analyzed for intensity modulated OCDMA system with dual homodyne correlation receiver using balanced detector. The receiver noises are included to obtain the generality for the receiver model as well as MUI. Rather than concentrating the study on the strategy for the code synchronization procedure followed by the computation of the average acquisition time as the performance of interest, the P_{fa} and P_{be} depending on the state of code phase alignment are on focus [4].

II. Periodic correlation properties for prime code sequences

Code sequences in CDMA systems require the following two properties: 1) each code in the set is easy to distinguish from a time-shifted version of itself and 2) each code in the set is easy to distinguish from every other code in the set [5]. The first property is important for the code auto correlation function determining the performance of code synchronization process, while the second for the cross correlation characteristics suggesting the influence of multiuser interference.

The periodic auto correlation function for code C_x is

$$R_{xx}(\tau)=\sum_{j=0}^{N-1} x_j \cdot x_{j\oplus\tau} \ , \ 0 \le \tau \le N-1 \qquad (1)$$

where $\oplus$ is the modulo N addition (N: code length), and the periodic cross correlation function for codes C_x and C_y is

$$R_{xy}(\tau)=\sum_{j=0}^{N-1} x_j \cdot y_{j\oplus\tau} \ , \ 0 \le \tau \le N-1 \qquad (2)$$

The prime code shows the difference in the property of code correlation functions compared to those of the conventional