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Optical CDMA Networks Using Extended Hamming Code for Interference Elimination

Chao-Chin Yang[1] and Larn-Ying Yeh [2]
Dept. of Electronic Engineering, Kun Shan University, Taiwan.
[1]E-mail : ccyang@mail.ksut.edu.tw
[2]E-mail : yehyu@mail.ksu.edu.tw

Abstract

One spectral-amplitude-coding scheme employing extended hamming code for optical code division multiple access networks is present. By using this scheme, each user can adopt complementary coding for information encoding with lower bit error rate.

1 Introduction

Optical code-division multiple-access (OCDMA) techniques are promising solutions for optical access and local area networks. Among these techniques, the spectral-amplitude-coding (SAC) scheme has received more and more attention due to its excellent interference elimination ability [1]. Besides, its complementary coding ability is also suitable for the applications of other OCDMA schemes such as time-spreading/wavelength hopping OCDMA with enlarged cardinality and improved performance[2].

In [3], one SAC scheme cooperating with wavelength division multiplexing for coder simplification was proposed. However, this scheme doesn't have complementary coding ability. The following scheme is proposed to alleviate this drawback.

2 System description

The proposed scheme uses the well-known Extended Hamming (EH) code for codeword construction[4] [5]. The codewords of extended [8,4] Hamming code $X_{m,n}$ are listed in Table I (m=0,…, M-1 and n=0,1.) Note that these codewords are generated from the generator matrix of [7,4] Hamming code and added by an overall parity-check bit. The Hamming distance between these extended [8,4] Hamming code is

Table I: Extended [8,4] Hamming code.

m	$\mathbf{X}_{m,0}$	$\mathbf{X}_{m,1}$
0	11111111	00000000
1	10000111	01111000
2	01001011	10110100
3	11001100	00110011
4	00101101	11010010
5	10101010	01010101
6	01100110	10011001
7	11100001	00011110

$$d(X_{m,n}, X_{q,r}) = \begin{cases} 0, m = q, n = r, \\ 8, m = q, n \neq r, \\ 4, m \neq q. \end{cases}$$

Thus

$$X_{m,n} \odot X_{q,r} = \begin{cases} 4, m = q, n = r, \\ 0, m = q, n \neq r, \\ 2, m \neq q, \end{cases}$$

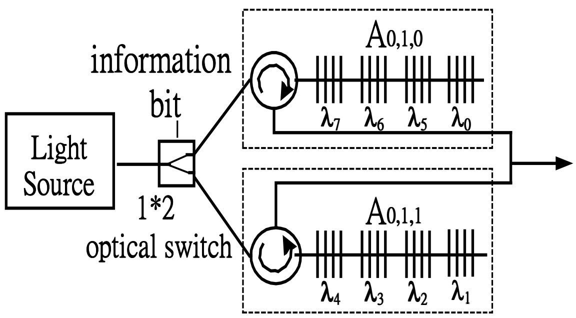
where $\odot$ is the dot-product of two vectors[6]. Note that the above property is not valid for $X_{0,1}$, thus $X_{0,0}$ and $X_{0,1}$ are not used in the proposed scheme. By using the method of code construction in [3], WS-EH codewords $\boldsymbol{A}_{\boldsymbol{u},m,n}$ can be obtained from $X_{m,n}$, where u is the group number(u = 0, 1, …, N-1). $\boldsymbol{A}_{\boldsymbol{u},m,0}$ and $\boldsymbol{A}_{\boldsymbol{u},m,1}$ are assigned to user#(u, m) for the encoding of "1" and "0" bits, respectively. As an example, the encoder of user#(0, 1) using $\boldsymbol{A}_{0,1,0}$=[1 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0] and $\boldsymbol{A}_{0,1,1}$=[0 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0] as signature sequences is shown in Fig. 1 for N=2. The encoder contains light source, 1*2 optical switch, circulators and fiber Bragg gratings with different center wavelengths[3]. According to the information bits, the wavelength signals from the light source are directed to one of the upper or lower circulator inputs in Fig. 1(a) by the 1*2 optical switch, and spectrally encoded by one of the fiber Bragg grating arrays. The resulting signals are directed by the same circulator again and appear at the output port of the encoder.

The decoding scheme for user#(u, m) to eliminate interference from user#(v, q) is

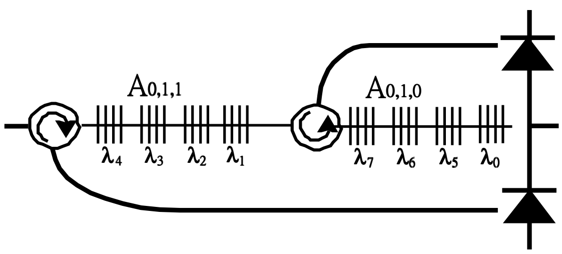
$$A_{u,m,0} \odot A_{v,q,r} - A_{u,m,1} \odot A_{v,q,r}$$

$$= \begin{cases} 4, & u=v,\ m=q,\ n=0, \\ -4, & u=v,\ m=q,\ n=1, \\ 0, & \text{otherwise}, \end{cases}$$

and it can be implemented simply using optical components. One example is the FBG-based decoder shown in Fig. 1(b).



(a)



(b)

Fig. 1. The encoder and decoder for WS-EH codes.

3 Performance Analyze

By using the method as that in [3], the relationship between bit error rate (BER) and number of active users can be obtained, as shown in Fig. 2. In addition to

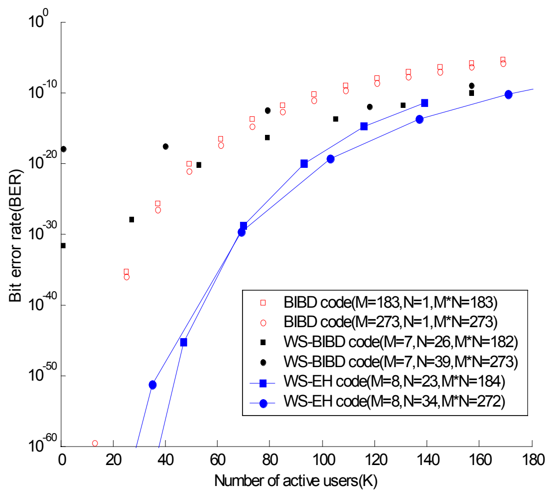


Fig. 2. BER versus number of active users.

WS-EH codes proposed here, the results for BIBD codes and WS-BIBD codes in [3] are also shown for comparison and the code lengths of these code families of Fig. 2 are about 183 or 273. It is found that when the the code lengths $M*N$ is fixed and the number of active users is smaller, the WS-EH codes obtains lower BER as compared to that of the other two code families. When the number of active users become larger, the BERs of these code families are getting closer. In addition, it should be noticed that the encoder of the WS-EH codes is more complex than that of WS-BIBD codes. Thus the selection of suitable code families should be careful.

4 Conclusion

We propose one code family using EH codes for SAC OCDMA networks. These codewords can be used for complementary coding and the BERs are lower than that of previous proposed code families when the number of active users is relatively small.

5 References

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