파장/시간의 2차원 코드를 사용한 광 부호 분할 다중 접속 부호기/복호기의 성능 분석

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Performance Evaluations on Shared-Type Encoder/Decoder with Wavelength/Time 2-D Codes for Optical CDMA Networks

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Abstract - For large capacity optical CDMA networks, we propose a shared-type encoder/decoder based on an tunable wavelength conveter (TWC) and an arrayed waveguide grating (AWG) router. Feasibility of the structure of the proposed encoder/decoder for dynamic code allocation is tested through simulations using three types of wavelength/time 2-D codes, which are the generalized multi-wavelength prime code(GMWPC), the generalized multi-wavelength Reed-Solomon code(GMWRSC) and the matrix code.

Test results show that the proposed encoder/decoder can increase the channel efficiency not only by increasing the number of simultaneous users without any multiple-access interference but by using a relatively short length CDMA codes.

1. Introduction

In conventional 2-D optical CDMA system, each user needs a specific fixed encoder/decoder which results in very lengthy CDMA codes or huge amount of hardware for a large system. Users who share the encoder/decoder can cause collision between the users when each user transmits the same code simultaneously. We solved this problem by employing a new dynamic code allocation scheme based on the control of code wavelength by TWC.

The proposed system uses a group of encoder/decoder for many simultaneous users to share by employing AWG. Feasibility of the structure of the proposed encoder/decoder for dynamic code allocation is tested through simulations using three wavelength/time 2-D codes, which are the generalized multi-wavelength prime code (GMWPC)[1], the generalized multi-wavelength Reed-Solomon code (GMWRSC)[1] and the matrix code[2].

2. Shared Encoder/decoder Structure

The wavelength that connects the i th input to the j th output of the $N \times N$ AWG can be expressed by

$$\lambda(i,j) = \lambda_q \qquad (1)$$

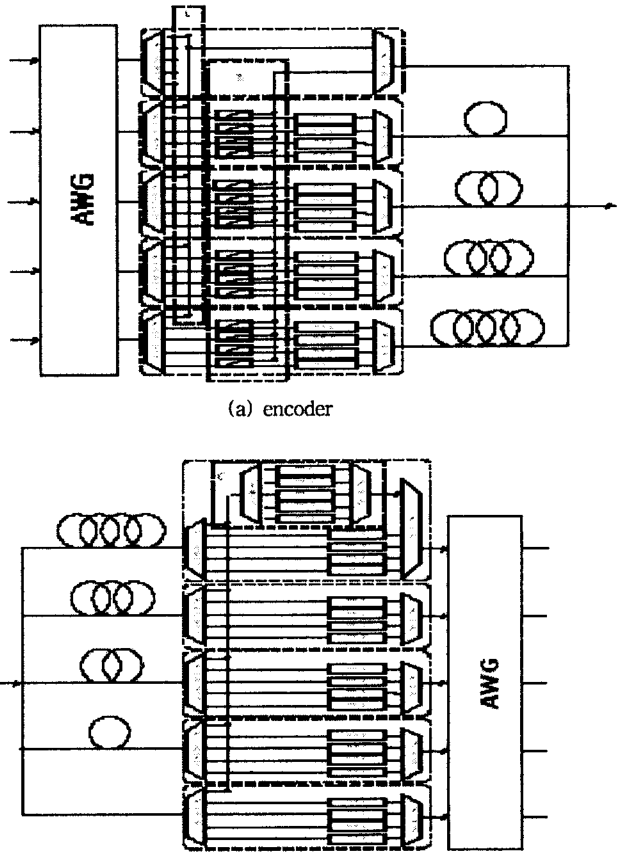
where the subscript q is determined by $q = i+j$ (modulo N) [3]. Using this AWG routing characteristics, several simultaneous users can share the encoder. The collision between users can be avoided easily by appropriate control of output wavelengths of TWC.

We now use the GMWPC, GMWRSC and the matrix code as wavelength/time 2-D codes for our shared-type encoder/decoder. The encoder/decoder configurations for (5×5,5,0,1)GMWPC is shown in Fig. 1. The encoder/decoder configurations for (7×6,6,0,1)GMWRSC is given in [3].

3. Simulation Results

Based on the tree network topologies of GMWPC, GMWRSC for 5 users and matrix code for 6 users using Optsim software package, simulation results for detection of any specific user code show that the proper choosing of the threshold level at the detector gives the results that the data can be recovered back to its original values. Fig. 2 reprents the detection results of C_3 with bit stream of "11011010" for matrix code. Detection results for GMWPC and GMWRSC are given in [3].

The encoder/decoder for the matrix code does not need TWC so that the system becomes simpler compared with other two cases. Compared with GMWPC and GMWRSC, the bit error rate of the matrix code increases due to the use of more wavelengths for the same number of users. System complexities of three codes are given in Table 1.



(a) encoder

(b) decoder

Fig. 1. Configuration of the shared-type encoder/decoder with (5X5,5,0,1)GMWPC.

Table 1. Comparison of system complexities for three codes.

Parameter / 2-D codes	Wavelength channels	Code length	AWGs	TWCs	mux /demux
GMWPC	5	5	2	50	21
GMWRSC	5	4	2	10	5
Matrix Code	8	4	2	-	1

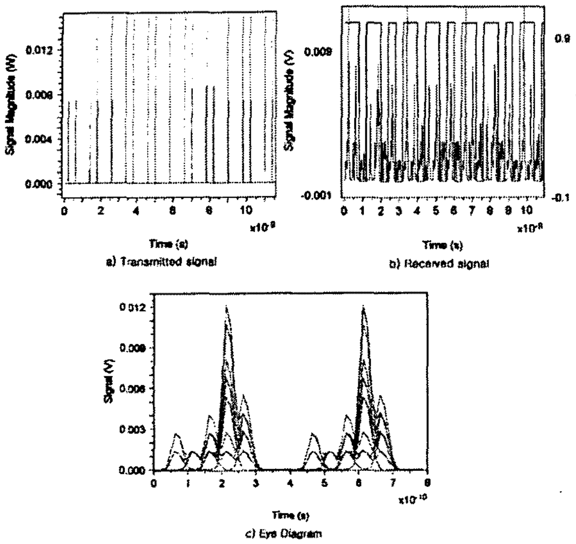


Fig. 2. Detection of C_3 with bit stream of "11011010" for matrix code.

4. Performance Analysis

The performance of encoder/decoder is determined by the band-width efficiency of the used optical codes which is closely related with the error probability of the code in multiple user circumstance as well as the code size dependent on the code length. To analyze the performances of GMWPC and GMWRSC codes in our encoder/decoder, we assume chip synchronization because chip synchronization results in an upper bound of the performance.

4.1 Error Probability

The probability of one of the pulses in a signature code at any time chip is assumed to be $q=(1/2)(c/L)$, where c is the code weight, i.e., the number of pulses in a code, L is the code length, and the received data bit of 1 or 0 is equally probable. The error probability of $(p\times p,p,0,1)$GMWPC is given by

$$P_e = \frac{1}{2}\sum_{i=Th}^{M-1}\binom{M-1}{i}q^i(1-q)^{M-1-i} \qquad (2)$$

where Th and M are threshold level and total number of simultaneous users, respectively. The result in (2) can be modified to the error probability of $(p\times p,p-1,0,1)$GMWRSC by simply replacing q by $(p-1)/p^2$.

Fig. 3 shows the error probabilities versus number of simultaneous users M for GMWPC and GMWRSC for various prime number p based on Eq. (2). Due to the longer code length, the GMWPC performs better than the GMWRSC.

4.2 System Capacity

When N_w wavelength channels and N_t time chips are used to implement the 2-D codes, we have N_w for GMWPC and $N_wN_t/(N_w-1)$ for GMWRSC, respectively, orthogonal codewords. For a given N_w, more users can be accommodated by employing a larger number of time chips at the cost of narrower user bandwidth. In this case, however, the number of simulataneous users M also decreases rapidly as the guaranteed error probability becomes lower, and thus the system capacity decreases. For the case where $N_w=p$, $N_t=p$ for GMWPC and for GMWRSC with the same error probability of 10^{-9}, the normalized system capacity M/N_t is plotted as a function p of in Fig. 4.

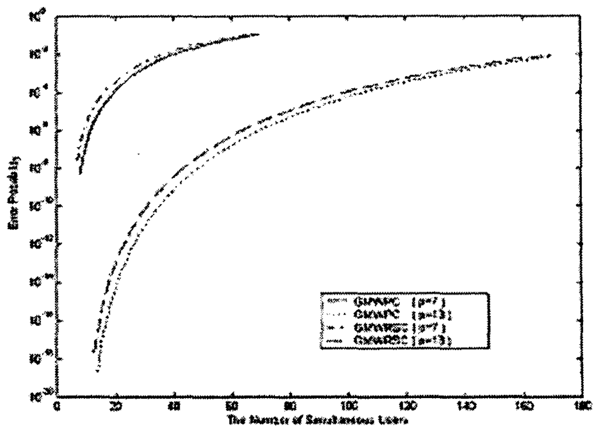


Fig. 3. Error probabilities vs number of simultaneous users for GMWPC and GMWRSC.

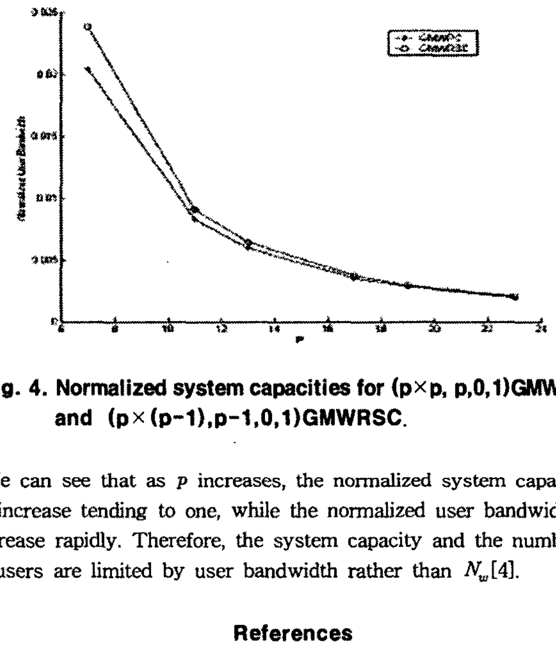


Fig. 4. Normalized system capacities for (p×p, p,0,1)GMWPC and (p×(p-1),p-1,0,1)GMWRSC.

We can see that as p increases, the normalized system capaciti es increase tending to one, while the normalized user bandwidths decrease rapidly. Therefore, the system capacity and the number of users are limited by user bandwidth rather than N_w[4].

References

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