PERFORMANCE COMPARISON OF TURBO CODED MC-CDMA AND DS-CDMA WITH HIGHER LEVEL MODULATION

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1. INTRODUCTION

Multi-carrier code division multiple access (MC-CDMA), direct sequence code division multiple access (DS-CDMA) and orthogonal frequency division multiplexing (OFDM) are the major contenders for wireless signaling technique. For higher data rates, the use of higher level data modulation is desirable. In MC-CDMA [1], the data-modulated symbol to be transmitted is spread over a number of subcarriers using an orthogonal spreading sequence defined in the frequency-domain. OFDM can be taken as a special case of MC-CDMA with a spreading factor *SF* of 1. On the other hand, in DS-CDMA, time-domain spreading is used; DS-CDMA with minimum mean square frequency-domain equalization (MMSE-FDE) [2] gives a performance comparable to that of MC-CDMA with MMSE-FDE in a frequency-selective fading channel. In all types of data transmission systems, some form of error control is needed to improve the transmission performance. Turbo coding has been found to provide strong error correction capabilities. In this paper, we evaluate by computer simulations, the bit error rate (BER) performance of the three systems when turbo coding is used for error control and higher level modulation like 16QAM and 64QAM are employed.

2. MC-CDMA and DS-CDMA

In MC-CDMA, the binary information sequence is turbo coded, bit-interleaved and transformed into a data-modulated symbol sequence. The symbol sequence is serial-to-parallel (S/P) converted to C streams and after each stream is spread in frequency-domain using different orthogonal codes, with spreading factor *SF*, they are code-multiplexed and further multiplied by a common scrambling sequence. Then, IFFT is performed and the signal transmitted after the guard interval (GI) insertion. At the receiver, FFT and MMSE-FDE is performed and is followed by frequency-domain despreading. After parallel-to-serial (P/S) conversion, data-demodulation is performed. Then, bit de-interleaving and turbo decoding is carried out. MC-CDMA system with $SF=C=1$ is an OFDM system.

In DS-CDMA, the spreading is done in time-domain in contrast to MC-CDMA. The code-multiplexing order for DS-CDMA is also taken to be C. GI required in DS-CDMA with MMSE-FDE [2] is inserted before the signal is transmitted. At the receiver, GI is removed, FFT, MMSE-FDE and IFFT operations are performed. Then, the chip sequence is despread and data-demodulated. Turbo coding/decoding and bit interleaving/ deinterleaving are similar to those in MC-CDMA.

3. SIMULATION RESULTS

We assume a frequency-selective Rayleigh fading channel having a 16-path uniform power delay profile with a time-delay spacing of $1T_c$ between adjacent paths and a normalized maximum Doppler frequency $f_DT_cN_c$ of 0.001, where T_c is the FFT sampling interval (equal to the chip duration) and N_c is the number of subcarriers (equal to the number of FFT points) for MC-CDMA (DS-CDMA). In the simulation, $N_c=256$ is assumed. GI is taken to be 32 samples (chips). $SF=C=256$ for MC-CDMA and DS-CDMA. A rate ½ turbo encoding with a constraint length 4 and decoding with 8 iterations is assumed. The data sequence length is taken to be 1024 bits. A 64x64-bit block interleaver is assumed.

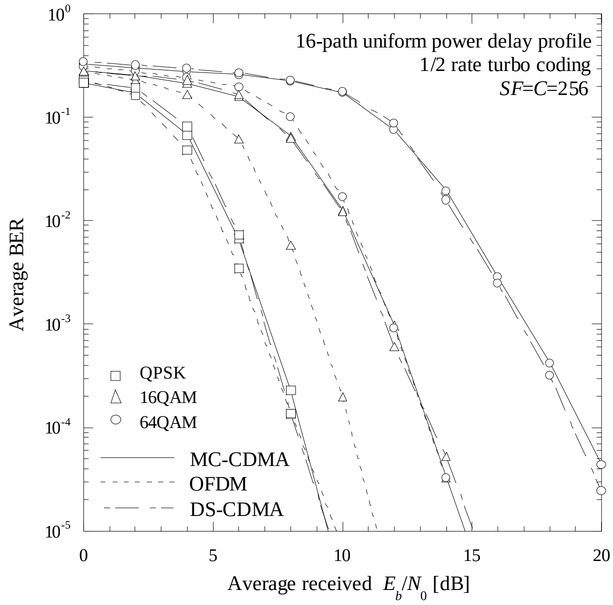

Fig 1 Performance comparison of OFDM, MC-CDMA, DS-CDMA.

Figure 1 plots the average BER for MC-CDMA, OFDM and DS-CDMA as a function of E_b/N_0 for QPSK, 16QAM and 64QAM. Higher *SF* has a higher frequency diversity effect in MC-CDMA, but at the same time, the orthogonality destruction is severer in a frequency-selective channel. MMSE-FDE is applied which partially restores the orthogonality. The performance for DS-CDMA is same, irrespective of the *SF*. For all the cases, the MC-CDMA curve with $SF=N_c$ and DS-CDMA curves coincide. OFDM has no frequency diversity gain when channel coding is not applied. However, with channel coding, OFDM also benefits from a large coding gain due to a large interleaving gain and provides almost similar performance to MC-CDMA and DS-CDMA. On the contrary, for 16QAM, the OFDM performance is better than that of MC-CDMA. This is because, for 16QAM, the distance between the signal points becomes shorter and the orthogonality destruction causes the MC-CDMA and DS-CDMA performance to be worse. Likewise, the OFDM performance is better than that of MC-CDMA for 64QAM.

4. CONCLUSION

The BER performances of OFDM, MC-CDMA, and DS-CDMA are compared for various modulation levels when turbo coding is used. It was found that for QPSK modulation, MC-CDMA, DS-CDMA and OFDM provide similar performance, but, for 16QAM and 64QAM, OFDM provides better performance due to severe orthogonality destruction in MC-CDMA and DS-CDMA.

REFERENCES

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