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SCCC-MCCDMA combination performance over multipath Rayleigh fading channel

أداء مجموع (SCCC-MCCDMA) خلال قناة الخفوت متعدد المسارات

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Abstract

This work presents the simulation of a Serially Concatenation Convolution Coding SCCC with Multi-Carrier Code Division Multiple Access (MC-CDMA) system over multipath fading channels. The decoding technique used in the simulation was iterative decoding since it gives maximum efficiency with six iteration. Modulation schemes that used are Phase Shift Keying (BPSK, QPSK and 16 PSK), along with the Orthogonal Frequency Division Multiplexing (OFDM). The channel models used are as specified in the Third Generation Partnership Project (3GPP) Technical Specification TS 25.101v2.10 with a channel bandwidth of 5 MHz. this includes the channels are indoor to outdoor/ pedestrian channel and Vehicular channel.

ألخلاصه

هذا العمل يقدم محاكاة (SCCC) مع (MCCDMA) خلال قناة الخفوت متعدد المسارات . تقنية فتح الشفرات المستخدمة في البحث هي فك الشفرات التكراري لأنه يعطي الكفاءة القصوى مع ستة تكرارات . نوعيات التضمين المتبعة هي (BPSK,QPSK,16PSK) مع (OFDM) . القناة المستخدمة في النموذج هي قناة الجيل الثالث (GPP3) ذات المواصفات التقنية TS 25.101v2.10 مع عرض قناة مقداره 5MHz وتشمل القنوات داخل وخارج ألابنيه والقنوات المتحركة .

Introduction

Future wireless systems such as fourth generation (4G) cellular will need flexibility to provide subscribers with a variety of services such as voice, data, images, and video. Meanwhile, multicarrier CDMA (MC-CDMA) has emerged as a powerful alternative to conventional direct sequence DMA (DS-CDMA) in mobile wireless communications [1, 2], that has been shown to have superior performance to single carrier CDMA in multipath fading. The attractive features derived from the CDMA-OFDM combination makes MC-CDMA a firm candidate for the next generation of wireless system [3, 4]. Since 1993, MC-CDMA rapidly has become a topic of research. Wireless mobile communication systems present several design challenges resulting from the mobility of users throughout the system and the time-varying channel (Multi-path fading). There has been an increasing demand for efficient and reliable digital communication systems. To tackle these problems effectively, an efficient design of forward error coding (FEC) scheme is required for providing high coding gain. To obtain high coding gains with moderate decoding complexity, concatenation of codes with iterative decoding algorithms has proved to be an attractive scheme.
In iterative decoding, instead of extracting all information from the received symbols and the knowledge about the code in a single run, it is done during several iterations with successively better reliability of the result. The reason the iterative code can perform better it that the cost is prohibitly high to extract all information in one run. On the contrary, iterative decoders only extract little new information during every iteration which is added to the previously extracted information.

MC-CDMA System Description

The generation of an MC-CDMA signal can be described as shown in Figures 1 and 2, a single data symbol is replicated into N parallel copies. Each branch of the parallel stream is multiplied by one chip of a spreading code of length N [5]. The resulting chips are then fed to a bank of orthogonal subcarriers. As is commonly done in MC-CDMA, it is assumed that the spreading sequence length N equals the number of subcarriers. However, this scheme can be generalized to the case where the number of carriers is a multiple of the spreading sequence length allowing in this way the simultaneous transmission of several symbols from the same user. Carrier modulation is efficiently implemented using the inverse fast Fourier transform (IFFT) [6].

After parallel-to-serial (P/S) conversion, a cyclic prefix (CP) is appended to the resulting signal to minimize the effects of the channel dispersion. It is assumed that the CP length exceeds the maximum channel delay spread and therefore, there is no interference among successively transmitted symbols (i.e. there is no interblock interference).

The transmitted signal corresponding to the kth data bit of the mth user ($a_m[k]$) is

$$S_m = \sum_{i=0}^{N-1} c_m[i]\, a_m[k] \cos(2\pi f_c t + 2\pi i \frac{F}{T_b} t)\, p_{T_b}(t - kT_b) \qquad 1$$

$$c_m[i] \in \{-1, 1\}$$

where $c_m[0]$, $c_m[1]$, ... , $c_m[N-1]$ represents the spreading code of the mth user and $p_{Tb}(t)$ is defined to be an unit amplitude pulse that is non-zero in the interval of [0, Tb]. The input data symbols, $a_m[k]$, are assumed to takes on values of -1 and 1 with equal probability.

At the receiver side, opposite operation to that done at the transmitter are done. These operations are the OFDM demodulation, dispreading, MPSK demodulation, demapping and the SCCC decoding.

Serial concatenated convolutional encoding

The structure of a serially concatenated convolutional code (SCCC) is shown in Figure 3. In SCCC, only the inner code must be recursive systematic convolutional RSC. The information bits are encoded by the outer encoder and the resulting code bits are interleaved by the bit wise random interleaver and become the information bits of the inner encoder. The outer code with a rate $R_o = k/p$ and the inner code with rate $R_i = p/n$ joined by an interleaver of length N bits, generating an SCCC with rate $R_c = k/n$. Note that N must be an integer multiple of p [7].

A corresponding decoder for the SCCC shown previously is shown in the Figure [4]. One important feature of turbo codes is the iterative decoding which uses a soft-in/soft-out (SISO) like MAP decoding algorithm which was first applied to convolution codes by Bahl Cocke, Jelink and Raviv.

In MAP [8] decoding scheme the fact that it gives the maximum MAP estimate of each individual information bit is crucial in allowing the iterative decoding procedure to converge at very low SNR's although SOVA [8] can also be used to decode turbo codes but a significant improvements can be obtained with MAP algorithm. This algorithm requires a forward and backward recursion and is therefore suitable for block oriented processing since turbo code is a block oriented process this algorithm. The MAP algorithm calculates the posterior probability (APP) of each state transition massage bit.

The decoding is done for each inner code vector. The decoded bits are then decoded again according to the outer code used [9]. It consists of two soft input soft output SISO [10, 2] modules connected in a ring.

Simulation results

The proposed system is illustrated in Figure [5]. An 20 Mbps was transmitted over the system. Since the channel for the 4th generation is not developed yet, therefore, the 3.5 G channel specifications was used in the simulation process. These channels are indoor to outdoor/ pedestrian

channel and Vehicular channel. The modulation schemes are the MPSK with M=2, 4 and 16. The simulation was performed using Matlab program version R2008a.
The system uses the convolutional code (CC) with the Viterbi decoding algorithm and serial concatenated convolutional code (SCCC) with the MAP decoding algorithm which is an iterative decoding algorithm. The performance of the serial concatenated convolutional code system depends upon the number of iteration of the decoder.
Table [1] summaries the system specifications for the indoor to outdoor/ pedestrian environment for AWGN channel and frequency selective fading channel.
Figures [6, 7 and 8] show the variations of BER versus signal to noise ratio (SNR) (E_S/N_o signal power to the noise power) for AWGN channel for uncoded data, convolutional coded data and serial concatenated convolutional coded data.

Table 1-**Simulation parameters for the indoor to outdoor/pedestrian environment**

Outer encoder octal	(3, [7 5],7)
Inner encoder octal	([3 3], [7 0 5; 0 7 6], [7 7])
Available bandwidth	5 MHz
FFT sampling rate	5 MHz
Spreading code	Hadamard Walsh
Spreading factor	64
FFT size	2024
Subcarrier spacing	2.4414 kHz
Effective symbol duration	409.6 μs
Guard time duration	102.4 μs
MC-CDMA symbol duration	512 μs
Modulation technique	BPSK, QPSK, 16PSK & 256PSK
No. of iterations	6

Figures [9, 10 and 11] show a comparison for the uncoded, convolutional coded and serial concatenated convolutional coded data for the fading channel.
Table [2] summaries the system specifications for the Vehicular channel while Figures[12,13 and 14] illustrate the BER variations versus SNR for the multipath Vehicular channel and the uncoded, convolutional coded and serial concatenated convolutional coded data.

Table 2- Simulation parameters for the vehicular environment

Outer encoder octal	(3, [7 5],7)
Inner encoder octal	([3 3], [7 0 5; 0 7 6], [7 7])
Available bandwidth	5 MHz
FFT sampling rate	5 MHz
Spreading code	Hadamard Walsh
Spreading factor	64
FFT size	2048
Subcarrier spacing	2.4414 kHz
Effective symbol duration	409.6 μs
Guard time duration	102.4 μs
MC-CDMA symbol duration	512 μs
Modulation technique	BPSK, QPSK, 16PSK & 256PSK
No. of iterations	6

Table [3] summarizes the obtained results as a comparison for the selected channels; AWGN channel, Multipath fading channel and Vehicular channel for modulation techniques of bpsk, 4psk

and 16psk with uncoded, convolutional coded (CE) and serially concatenated convolutional coded data.
It can be noticed that there is an improvement in the results of the use of the SCCC data over the others in many dB's of SNR. For Vehicular channel it can be noticed for both uncoded and convoluional coded data, in the case of 16psk modulation, they never arrived the 10^{-4} of the BER while the SCCC gives a good results. The same can be noticed for the indoor to outdoor pedestrian channel for 16psk modulation.

Table [3]: A comparison for SNR in dB for Uncoded, CE and SCCC for bpsk, 4psk and 16psk for BER of 10^{-4}.

Mpsk	SNR/dB for AWGN channel			SNR/dB for indoor to outdoor// pedestrian channel			SNR/dB for Vehicular channel		
	Uncoded	CE	SCCC	Uncoded	CE	SCCC	Uncoded	CE	SCCC
2psk	17	13	9	21.5	17	12.7	22.5	17.5	14
4psk	21	15	13	25	19	17	29	23	18
16psk	29	25	21	--	29	25	--	---	30

Conclusion:

For the Vehicular channel with serial concatenated convolutional coded data and for high SNR, the BER is below 10^{-3} for about 12 dB of SNR E_b/N_o and above. It is far away from that of uncoded and convolutional coded data. It still better for low SNR below 12 dB but the results contains a little difference from both uncoded data, convolutional coded data.
The simulation results showed that, at a BER of 10^{-4}, the performance of the MC-CDMA system over the Vehicular channel with SCCC coding scheme is better than that at convolutional coding one by about 3.5 and 5 dB for bpsk and 4psk modulation schemes respectively. And for the indoor to outdoor/pedestrian channel by about 4.3, 2 and 4dB for bpsk 4psk and 16psk modulation schemes respectively.

References

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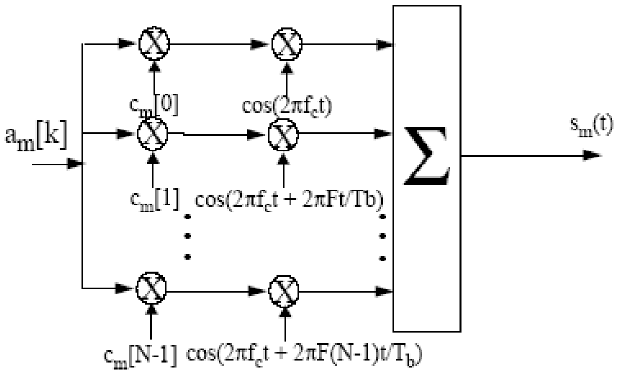

Figure (1) MC-CDMA transmitter

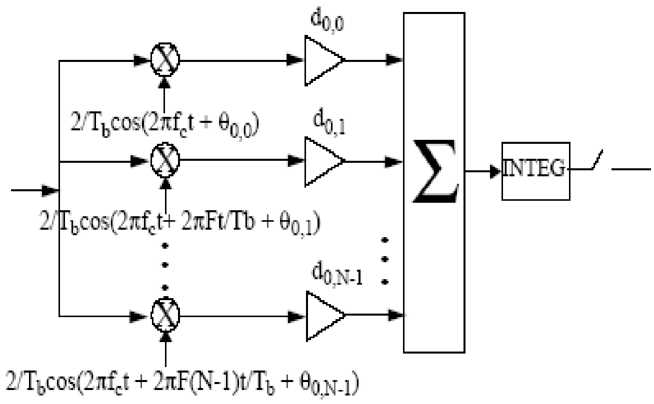

Figure (2) MC-CDMA receiver

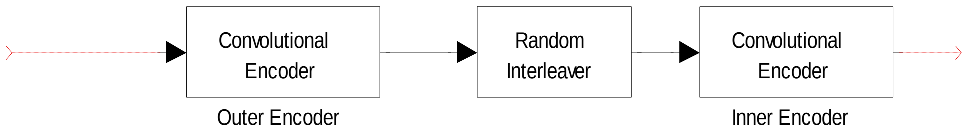

Figure (3) SCCC encoder

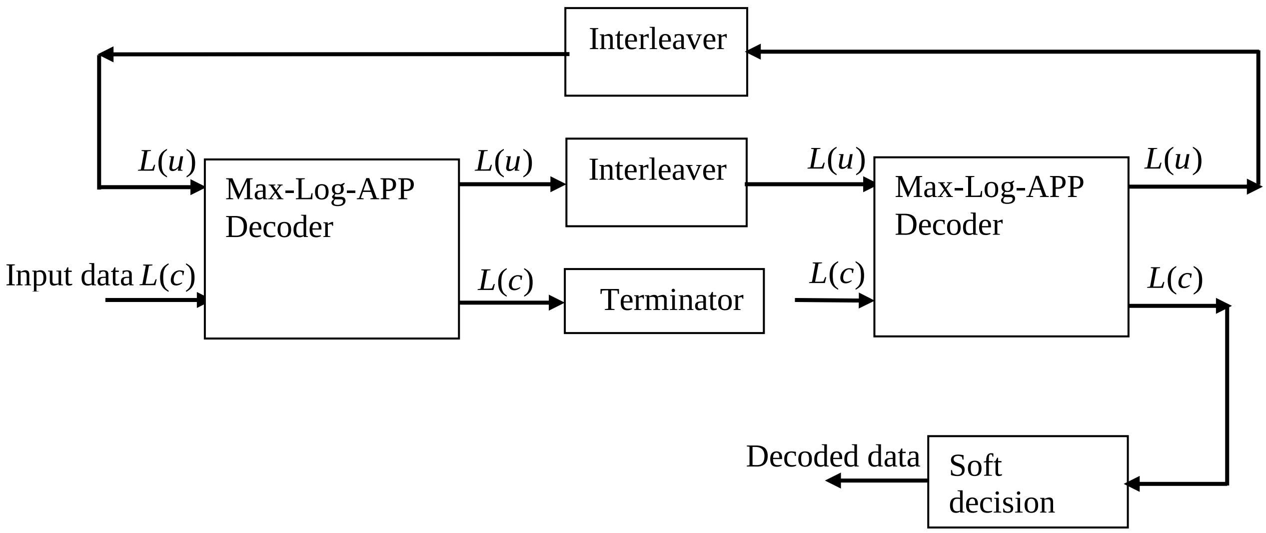

Figure (4) block diagram of the Max-Log-MAP decoding for the SCCC scheme.

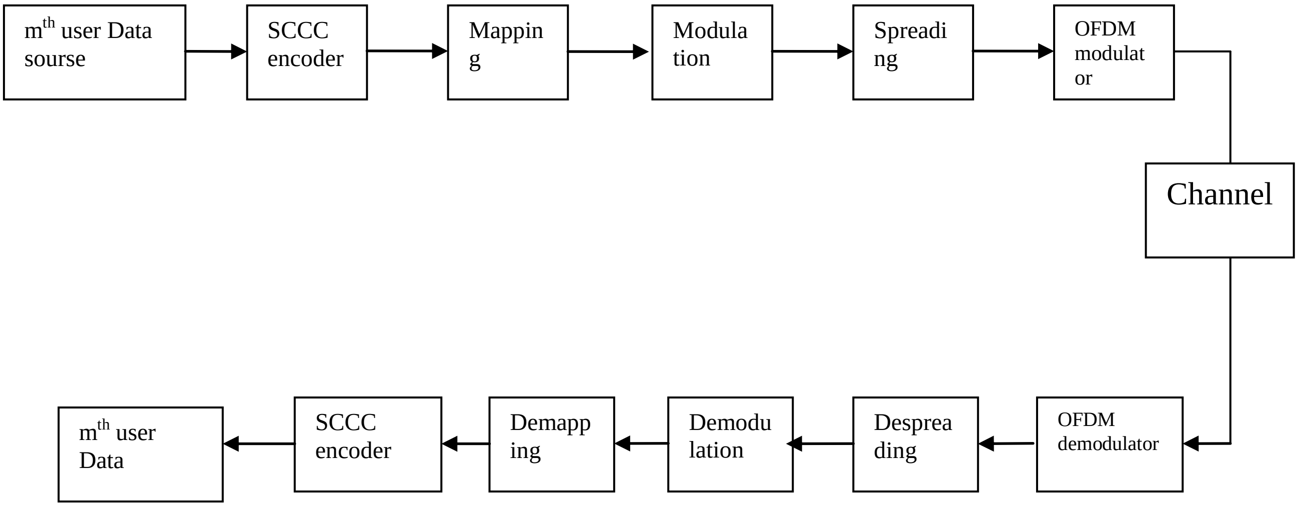

Figure (5) block diagram of the serially convolutional coded MC-CDMA system.

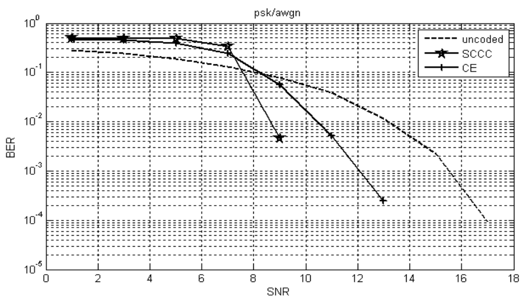

Figure (6) BER Vs SNR for **AWGN** channel with M=2

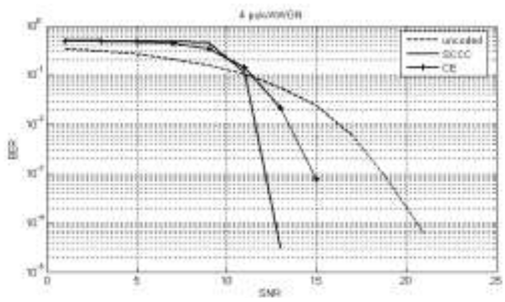

Figure (7) BER Vs SNR for **AWGN** channel with M=4

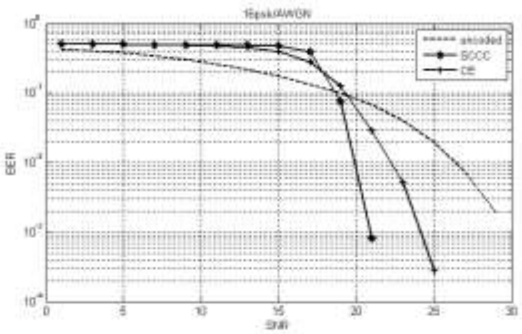

Figure (8) BER Vs SNR for **AWGN** channel with M=16

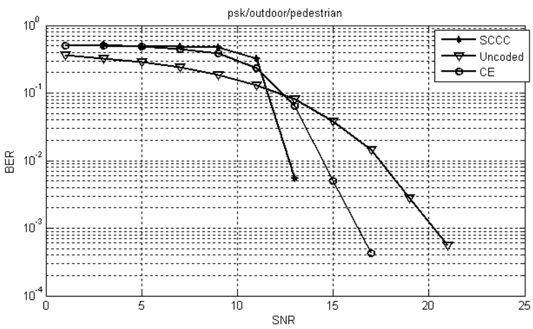

Figure (9) BER Vs SNR for **indoor to outdoor/pedestrian** channel with M=2

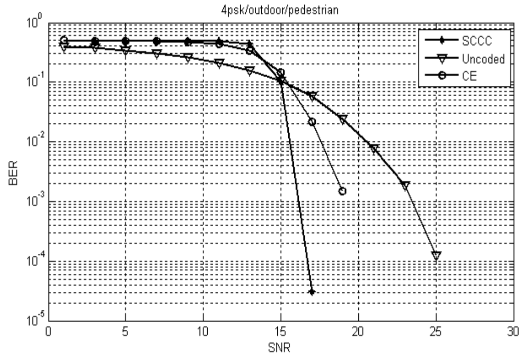

Figure (10) BER Vs SNR for **indoor to outdoor/pedestrian** channel with M=4

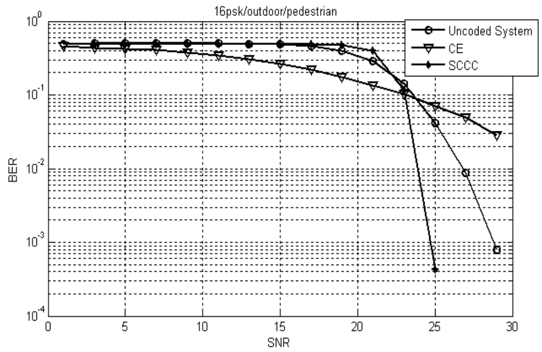

Figure (11) BER Vs SNR for **indoor to outdoor/pedestrian** channelwith M=16

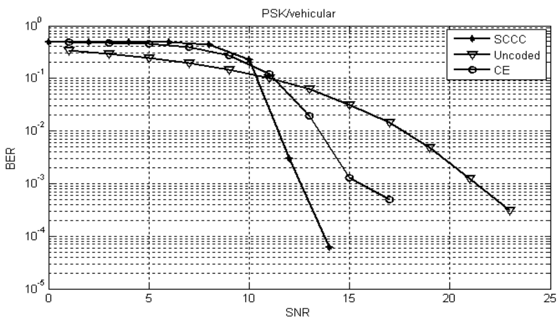

Figure (12) BER Vs SNR for **Vehicular** channel with M=2

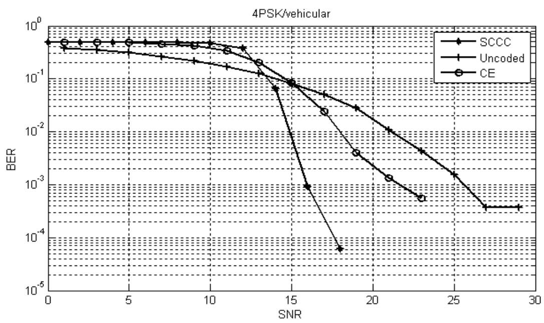

Figure (13) BER Vs SNR for **Vehicular** channel with M=4

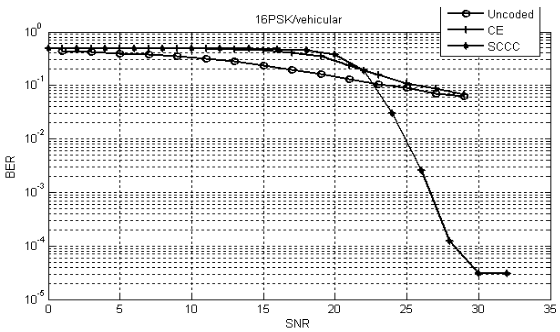

Figure (14) BER Vs SNR for **Vehicular** channel with M=16