Multicode Techniques in 4G

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Abstract—Orthogonal Frequency and Code Division Multiplexing (OFCDM) is a multicarrier transmission scheme which has been proposed for 4 generation to provide high speed mobile services. The system performance was tested and compared with previous MIMO OFCDM systems using 1D OVSF codes because of the better correlation properties of the 2D OVSF codes in comparison with 1D OVSF codes an improvement in system performance of OFCDM with 2D OVSF codes is observed on the basis of increases in throughput of system cause decrease in (bit error rate) BER and (multi code interference) MCI cancellation with increase in signal to noise ratio and showing simulation result for this.

Key Words— 4G, MIMO OFDM, MIMO 2D-OVSF OFCDM, 1D OVSF Codes , 2D OVSF Codes.

I. INTRODUCTION

With the rapid growth of user demands, fourth generation (4G) mobile communication systems are expected to become a platform capable of providing richer multimedia services to the users in comparison to the established 3G systems. This effectively requires an increase in the data rate. High data rate is required for services such as broadcast, thereby making it essential to increase the downlink capacity. 4G systems target a peak data rate of 100 Mbps with a bandwidth of 50–100 MHz in the downlink. Multicarrier modulation techniques are widely being adopted for this purpose. They have shown good results in terms of combating multipath interference. 4G will provide access to wide range of telecommunication services, including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet based, along with a support for low to high mobility applications and wide range of data rates, in accordance with service demands in multiuser environment.

Orthogonal frequency division multiplexing (OFDM) is one useful multiplexing scheme that has attracted many researchers. It divides data into a set of parallel streams to be transmitted using mutually orthogonal frequency bands. Because of this orthogonality, the data streams can be transmitted at the same time to increase the system transmission rate. On the other hand, CDMA is one form of “spread-spectrum” signaling that is broadly used in telecommunication systems. In a CDMA system, users are assigned orthogonal codes so that different users can share the same frequency band at the same time with little or no interference. One integration of OFDM and CDMA techniques, called OFCDM, takes advantage of both OFDM and CDMA systems to gain frequency diversity and achieve high but flexible transmission rates.

With two-dimensional spreading, OFCDM is an attractive transmission technique for high-data-rate applications. In OFCDM, spreading in frequency domain provides frequency diversity gain. On the other hand, a large time domain spreading factor allows more users to access the system at the same time, where as a small time domain spreading factor is more suitable for high-data-rate applications. Combined with MIMO technology, a MIMO-OFCDM system can provide high reliability with flexible transmission rates. We can therefore expect a great potential from MIMO OFCDM systems. Recently, many studies have been carried out for OFCDM systems on how to gain frequency domain diversity and on the effect of multi-code interference (MCI) on achieving this diversity.

The developed OFCDM system uses 1D orthogonal variable spreading factor (OVSF) codes. 1D OVSF codes have been widely used to characterize users and user services in the downlink channel by simultaneously preserving the orthogonality between different channels. 1D spreading sequences do not possess zero cyclic autocorrelation side lobes and cross-correlation functions. Hence, by using an alternative code set the system performance can be increased. 2D spreading sequences can be constructed that have zero cross correlation properties. One such class of 2D codes is 2DOVSF codes. 2D OVSF codes possess correlation properties that mitigate multipath and multiuser interference.

II. 2D-OVSF OFCDM SYSTE
should be designed in such way to take advantage of the orthogonality in time domain. Specifically, the spreading code generator minimizes the number of frequency domain OVSF spreading codes used. Therefore, the level of MCI is minimized.

Here we use an example to illustrate how to generate the spreading codes. When \( NF = 2 \) and \( NT = 4 \), \( C(0) \) is generated by

\[
\begin{align*}
CF(0) &= [1 1] & CT(0) &= [1 1 1 1] \\
C(0) &= CF(0) \times CT(0) &= \begin{bmatrix} 1 & 1 & 1 & 1 \end{bmatrix} \\
C(1) &= CF(0) \times CT(1) \\
C(2) &= CF(0) \times CT(2)
\end{align*}
\]

So forth………

Until time domain OVSF spreading code is used up. The code generator will change the frequency domain OVSF spreading code and restart the cycle.

\[
\begin{align*}
CF(1) &= [1 -1] & CT(0) &= [1 1 1 1] \\
C(4) &= CF(1) \times CT(0) &= \begin{bmatrix} -1 & 1 & -1 & -1 \end{bmatrix} \\
C(5) &= CF(1) \times CT(1) = \begin{bmatrix} 1 & -1 & -1 & -1 \end{bmatrix}
\end{align*}
\]

\( L = NF \times NB \) is the total numbers of subcarriers employed in the OFCDM system. \( L \times NT \) OFCDM symbol is constructed. Code multiplexer is used to provide more flexibility in system design. To increase data rate a multimode technique can be used. Known pilot symbol with data symbol for error correction it spread only in time domain SF is NT and for data SF in time domain is NT-1. Inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT) is used for conversion process. Cyclic prefix insertion maintains orthogonality between subcarrier, it gives extension to signal and make symbol periodic longer. Allow to signal to be decoded even if the packet is detected after some delay. To make synchronous operation of transmitter and receiver scrambler and descrambler is used. For band limitation and elimination of (inter symbol interference) ISI pulse shaping filter is used. Matched filter is important to filter out what signal reflections do occurs in the transmission process. In the receiver section, received signal passed via a co-ordinate filter. The cyclic prefix is removed in the received section, the resultant signal is descrambler and down converter by FFT transform. The output of the descrambler is given to the two dimensional DE spreader and decoded as well as demodulated by the code channel and recover the original signal. with the additional of two Different user data is spread with different frequency domain spreading code and same time domain spreading code MCI generated \( K > NT \). \( K \leq NT \), data symbol transmitted by the same NF carriers are spread with same frequency domain spreading code but different time domain spreading code. No MCI will present. It is preferred to assign code with greater code distance among adjacent code channels \([SF1/2]+1-d_{\text{min}}\). Here \( d_{\text{min}} \) - the minimum length of strings of consecutive 1s or –1s in the element wise code product. Figure 2 showing the spreading of 1D-OVSF codes and figure 3 and 4 showing the dispreading of 1D-OVSF codes.
III. 2D SPREADING AND DE-SPREADING USING 2DOVSF CODES

Code multiplexing and 2D spreading in the OFCDM system described in Section is achieved by using 1D OVSF codes.

1) Spreading:

The proposed 2D spreading has been illustrated in Fig 5 The input data stream is sent over various code channels. Each code channel first modulates the data which is followed by a serial-to-parallel conversion. This gives a K × SF1 matrix of modulated data Here K = NC/NF is the number of parallel streams processed by each channel processor. NC is the number of subcarriers. In each stream, SF1 bits are simultaneously spread by K different2D spreaders. The spreading is carried out as follows first spreading: SF1 bits are spread by a 2D OVSF code square matrix of SF1 dimension, here NT = 8; NF = 4, SF1 =2. Such that the 1st bit is spread by first row, 2nd bit by second row and so on till the (SF1)th bit is spread by the last row of the matrix.

2) De-Spreading:

At the receiver, the received data is down converted. Furthermore, the serial data is converted to parallel form followed by cyclic prefix removal. This gives a matrix with NC rows and NT columns. FFT is performed on this matrix to demodulate the data. The demodulated data needs to be de-spread in accordance with the 2D spreading that was carried out at the transmitter with an aim to remove MCI caused because of code multiplexing of channels. The despreading has been shown in Fig. 6.In Figs. 6a and b, first de-spread is carried out using the code set with SF = SF2. Different system parameters are used when investigating the performance with MRC, EGC and MMSE combining. Here, the de-spreader employs either simple equal gain combining (EGC) or maximal ratio combining (MRC) combining to collect spread signals.EGC combining is suitable for modulation techniques such as binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK). However, higher modulation schemes require MRC combining. Figs. 6c and d shows the second de-spread. The code set has SF = SF1. Here, the de-spreader employs simple EGC combining to collect spread signals. Finally, the de-spread bits are de-interleaved to obtain a serial
data stream. This data stream is de-modulated to obtain the received data.

IV. RESULT AND ANALYSIS

The bit error rate (BER) performance of the MIMO OFCDM system can be evaluated where both simulation and analytical results are presented using MATLAB tool. Figure 7 shows the increase in performance of MIMO OFCDM system as compared to the MIMO OFDM system by decreases in BER with increases in signal to noise ratio cause MIMO OFCDM system have all the facility of MIMO OFDM and additional benefits like frequency diversity gain. Fig. 8 compares the performance of the MIMO OFCDM system using 1D OVSF codes against MIMO OFCDM system using 2DOVSF codes for achieving 2D spreading. The results are obtained by keeping a fixed SF = NT × NF, where NT = 8, NF = 4. One code channel is assigned for pilot data while the rest (NT−1) × NF channels are fully loaded with information bits. As can be seen, the proposed system gives improved results with respect to the 2×2 OFCDM system employing 1D OVSF codes. Percentage of decrease in BER of MIMO OFCDM system is calculated by graph plotted in figure 7 and 8.

V. CONCLUSION

Our simulation results show that for 2 transmitters and 2 receivers the effect of AWGN channel on MIMO OFCDM system with 1D OVSF codes and 2D OVSF codes in which the SNR is varied from 0 to 25 db. The corresponding BER is plotted, that shows that the BER is lowest for highest value of SNR. MIMO-OFCDM system have better performance than...
MIMO-OFDM. Improvement in MIMO-OFCDM system performance with decrease in BER with increase in throughput with 2D OVSF codes than 1D-OVSF codes. In next module we will study the MIMO-OFCDM system with M-D OVSF codes and we construct the system with different channel and observed the performance of MIMO-OFCDM system in 4G.

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