STUDY OF MUD IN OFDM-IDMA SYSTEM WITH CFO EFFECTS

Roopal Verma
GRD Institute of Management & Technology, Dehradun
Roopalverma121@gmail.com

Dr. Vishal Gupta
GRD Institute of Management & Technology, Dehradun
vishalrahi@gmail.com

Abstract:
In this paper we discussed the various features of OFDM and IDMA. This includes low multiple user detection with low cost with flexible adaption rate, it also include various diversities in frequency with spectral and power advantages. OFDM-IDMA scheme is also suitable for broadband wireless transmission, but the performance of OFDM-IDMA will degrade with the effect of CFO, as the ratio of maximum frequency to carrier spacing increases.

I. INTRODUCTION
Various multiple access technique like TDMA, CDMA, FDMA has been been used in wireless network for communication. But OFDM i.e orthogonal frequency division multiple access offers number of advantages over these multiple access techniques, such as this scheme can provide simple treatment against ISI and also reduces cross cell interference. The IDMA in combination with OFDM allow effective and simple turbo type iterative MUD algorithm which can be easily implemented to large number of users, for obtaining higher throughout. MUD (multiple user detection) also provides potential solution to MAI (multiple access technique) problem. IDMA also allow low cost chip by chip(CBC) MUD detection algorithm, but the complexity increases linearly with increase number of user as the path increase which concern for wideband system. To differentiate among different users random interleavers are used which help to distinguish among different signals, with avoidance of spreading of signals.

Frequency synchronization in OFDM-IDMA is an important factor in this scheme which is a disadvantage in terms of sensitivity to frequency synchronization error. Inter carrier interference (ICI) and multi user interference (MUI) occur due to the disturbance in orthogonality between subcarrier because of CFO (carrier frequency offset), CFO is caused due to misadjusted local oscillator used in the Doppler effect. This can damage multi-users detection in OFDM-IDMA.

II. OFDM-IDMA MULTI-STREAMSYSTEM

The OFDM-IDMA system is very advantageous in realizing MUD efficiently, which is also not effected by number of users and channel length. The transreceiver structure of OFDM-IDMA system shows in Fig. Suppose “k” users are using the system then the „k” coded signals are interleaved by interleavers (πk) which is specified to individual user. The output signal of interleaver is denoted by {xk(n)} which are then passed to IDFT block. The users are easily distinguishable by their interleavers, as each user has their own sub-carrier. At the receiving side the signals is passed through DFT and represented as [1]:

\[ R(n) = \sum_{k=1}^{K} H_k(n)x_k(n) + Z(n) \]

Here, \( H_k(n) \) denotes channel gain of \( n^{th} \) subcarrier for user \( k \), \( x_k(n) \) denotes AWGN at subcarrier \( n \), and
\[ \sum_{m \neq k} H_m(n) x_m(n) Z(n) \]
represents the interference plus noise components in \( R(n) \) with respect to user \( K \) at subcarrier \( n \). \( E_k(n) \) can be approximated by a Gaussian random variable from the central limit theorem.

The IDMA [2, 3] system is useful to distinguish different users and also allow low complexity iterative MUD technique. The received signal in IDMA system [1] can be written as

\[ r_n = \sum_{k=1}^{K} h_k(n) x_k(n) + Z(n) \]

\[ ... = h_k(n) x_k(n) + \xi_k(n) \]

Where \( h_k(n) \) is fading coefficient seen by user „k“ at time \( n \), \( \{z(n)\} \) are samples of additive white Gaussian noise (AWGN), and \( \xi_k(n) = \sum h_k(n) x_k(n) + Z(n) \) represents the interference plus noise component in \( r(n) \) with respect to user „k“ at time \( n \).

The similarity between Equation 2 and 4 represent that the principle used in IDMA system can be applied to OFDM-IDMA system. Which help to ensure uncorrelated transmitted sequences from different users. This may not use matrix operation necessarily and simple CBC detection is sufficient to provide optimal performance. This mainly removes MUD problems in its applications.

### III. STUDY OF SIMULATION RESULTS AND PERFORMANCE

Sensitivity of OFDM-IDMA system with CFOs is shown in figure 3 and figure, which shows theoretical analysis and simulation results of sensitivity with CFOs in OFDM-IDMA systems. The results are based on BER performance in multipath channels with CFOs of uplink OFDM-IDMA when un-coded system is considered. The results consists data length of 128, with QPSK and AWGN channel model and two path modes, with 10 iterations. Figure 3 and Figure 4 [4] shows different marked parameters showing that the system can tolerate small CFO and maintain the performance. The performance rapidly degrades of the growing ratio of maximum frequency offset to carrier spacing.

![Figure 3: BER performance of OFDM-IDMA for same CFO for one user.](image)

![Figure 4: BER performance of OFDM-IDMA for same CFO for four users.](image)

Figure 5 and Figure 6 shows the sensitivity of carrier frequency offset on OFDM-IDMA system. Figure 5 illustrates the BER performance for different CFO in OFDM-IDMA system and Figure 6 illustrates the BER performance of OFDM-IDMA systems with both positive and negative CFO, having same performance.

![Figure 5: BER performance of OFDM-IDMA with different CFO for four users.](image)
CFO effect on OFDM system produce signal distortions yielding interference and power loss which degrades the system performance [5, 6], can be analyzed as [4]:

\[ R(m) = X_k(m)H_k(m)I_{m,m} + \sum_{m'=0}^{N-1} X_{k'}(m')H_{k'}(m')I_{m,m'} + W(m) \]  

For symbol at \( k^{th} \) subcarrier. Here \( X_k(m)H_k(m)I_{m,m} \) is the desired signal and \( \sum_{m'=0}^{N-1} X_{k'}(m')H_{k'}(m')I_{m,m'} + W(m) \) the CFO induced MAI from other subcarriers. \( I_{m,m'} \) is fading factor represents interference coming from sub-carrier \( m' \) to subcarrier \( m \).

\[ I_{m,m'} = \frac{1}{N} \sum_{m=0}^{N-1} \left( 2\pi(m' + c_k)n/N \right) \exp(-jm) \]  

Here \( c_k \) is the CFO of user \( k \) and the sub-carrier \( m' \) belongs to sub-carrier of user \( k' \). \( W(m) \) is the AWGN with zero mean and variance \( \sigma^2 \).

From equation (3) we can achieve:

\[ R(m) = X_k(m)H_k(m) \sin\left[ k\angle e^{j\frac{\pi(m'-1)}{N}} \right] + \frac{\xi_k(m)}{\sqrt{\frac{N\sin\left[ e\pi k/N \right]}{2}}} \]  

Equation 7 helps to achieve MUI and ICI caused by carrier frequency offset for user k. IDMA detection [7] process can be carried after achieving R. In presence of CFO, MUD may be damaged and CFO may also affect the performance of OFDM-IDMA with increasing ratio of maximum frequency offset of carrier spacing.

### IV. DISCUSSION AND CONCLUSIONS

In this paper we studied the multiuser detection in OFDM-IDMA system with CFO effect on the uplink performance of OFDM-IDMA system and also MUI &ICI caused by CFO. We observe that the system can maintain its performance in presence of smaller CFO which gets worsened when CFO is increased.

We discussed the simulation results of BER for OFDM-IDMA system showing the performance with CFO. In conclusion, OFDM-IDMA system will be researched in the future work for improved data rate and lower BER.

### REFERENCE


