Iterative Interference Cancellation for Co-Channel Multicarrier and Narrowband Systems

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***Abstract*—Coexistence of narrowband (NB) and multicarrier technologies will be a major concern in next generation wireless communication systems due to the co-channel interference (CCI) problem. In this paper, an efficient CCI cancellation method is proposed that may be utilized for an improved coexistence. The method treats both co-channel signals as desired signals and enhances them in an iterative manner. Through computer simulations, it is demonstrated that it yields significant gains in the symbol error rate (SER) performance of both the NB and multicarrier systems. Its computational complexity is compared with the complexity of the joint demodulation technique and it is shown to be much lower.**

***Index Terms*— CDMA, Cognitive radio, Femtocell, NBI, OFDM, OFDMA, Successive Interference Cancellation, UWB.**

I. Introduction

Next generation physical (PHY) layer technologies such as Long Term Evolution (LTE) and WiMAX are multicarrier (MC) systems and can have a bandwidth up to 20 MHz. Relative to these technologies, 3G systems, including even wideband code division multiple access (W-CDMA) with its 5 MHz bandwidth, need to be considered as narrowband (NB). During the transition phase from 3G to 4G, various MC and NB systems might have to share the same spectrum, which will result in a severe performance degradation due to the co-channel interference (CCI).

Earlier examples of coexistence studies in the prior art include [1] and [2], which investigate the coexistence of CDMA and GSM systems. A contemporary example scenario, where coexistence of NB and multicarrier systems might be unavoidable, is the co-channel deployment of W-CDMA based femtocells with LTE based macrocells, which has not been studied in the literature to our best knowledge. Femtocells [3] are miniature cellular networks that have a communication range in the order of 10 meters. They can coexist with a macrocell network through either a split-spectrum approach, which leads to an inefficient spectrum utilization, or a shared-spectrum approach [4], [5], where CCI is a potential concern. The initial deployments of femtocells will be mostly based on CDMA based technologies, such as the W-CDMA. In the future, while macro-cellular networks migrate to wider-band multicarrier-based technologies such as LTE, it might be expected that it takes a longer time for the consumers to replace their existing 3G femtocells with their next-generation versions. Hence, an LTE based macrocell may need to coexist with a large number of 3G femtocells within its coverage area. In a shared-spectrum deployment, this would result in an interference from the macrocell at a femtocell, which needs to be cancelled at the femtocell. Similarly, a W-CDMA femtocell may be interfering to an LTE based mobile station (MS) nearby, which again needs to be mitigated at the MS. A particularly important scenario where interference cancellation may yield good gains for femtocell networks is for the restricted operation mode[1] of femtocells, where, the macrocell mobile stations (mMSs) are not allowed to make hand-off to the femtocell network even when the signal quality is superior at the femtocell. A different example is the coexistence of MC based ultra-wideband (UWB) systems with the relatively narrowband technologies. It has been shown in [6] that multiband OFDM interference may seriously degrade the performance of NB systems at low signal-to-interference ratios (SIRs).

In this paper, we treat both co-channel signals as desired signals and propose a method that combats CCI through enhancing both signals in an iterative manner. In the literature, iterative CCI cancellation was considered in [7] - [11], which typically focus on NB systems and consider that the interferer and victim use the same technology. In [7], it is emphasized that by exploiting the differences in signal features such as their delays, initial signal separation can be obtained, which considerably increases the efficiency of iterative interference cancellation.

In the current paper, we exploit the inherent initial signal separation that exists due to the multicarrier vs. single carrier natures of interfering signals as well as the fact that the information is in frequency domain for MC signal and in time domain for NB signal. The proposed method assumes availability of signal reception and transmission capabilities for both systems. At each iteration, each signal is demodulated and then regenerated based on the symbol decisions and the channel impulse response. This way, a better estimate of the signal is obtained. The regenerated signal is subtracted from the aggregate signal to obtain an estimation of the other co-channel signal. Through extensive simulations, it is proved that this method can provide a fundamental improvement in the performances of both systems in as few as three iterations. Our second contribution is a comparison of the computational complexity of the proposed method with the joint demodulation technique.

II. System Model

In this paper, two different CCI scenarios are considered. The first scenario involves a MC and NB coexistence, and the second one deals with a MC and CDMA systems coexistence. The MC system employed has an orthogonal frequency division multiple accessing (OFDMA) based PHY layer. In both scenarios, it is assumed that the primary receiver is the OFDMA receiver, i.e. perfect time and frequency synchronization to the OFDMA signal is ensured. This fact is illustrated in the diagram in Fig. 1, where it is demonstrated that synchronizing to the OFDMA symbols rather than NB symbols is necessary even if a targeted packet of NB symbols starts and ends somewhere in the middle of the OFDMA symbols.

[1] Also referred as the closed subscriber group (CSG) operation.

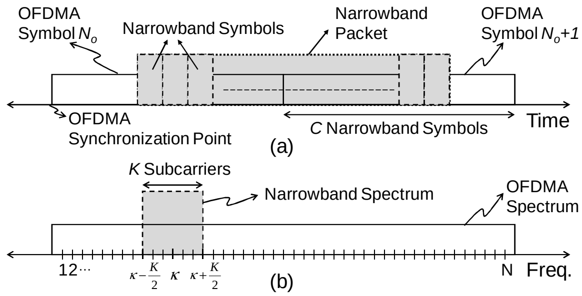

Fig. 1. Diagram of the OFDMA and NB symbols in time and frequency.

The sampled downlink OFDMA signal in time domain can be written as

$$x(n) = \sqrt{P_{\text{tx}}} \sum_{k=0}^{N-1} X(k) e^{j2\pi kn/N}, -N_{\text{cp}} \leq n \leq N-1, \quad (1)$$

where P_{tx} is the transmit power, N is the number of subcarriers, k is the subcarrier index, N_{cp} is the length of the cyclic prefix (CP), and $X(k)$ is the data on the kth subcarrier.

The received time domain OFDMA signal that traverses through a multipath channel $h(l)$ with L_{mc} taps is

$$y(n) = \sqrt{P_{\text{rx}}} \sum_{l=0}^{L_{\text{mc}}-1} h(l) x(n - D_l) \ , \quad (2)$$

where P_{rx} is the received signal power, and D_l is the delay of the lth tap. Assuming that the maximum tap delay does not exceed the CP length, the frequency domain OFDMA signal can be shown as

$$Y(k) = \sqrt{P_{\text{rx}}} X(k) \sum_{l=0}^{L_{\text{mc}}-1} h(l) e^{-j2\pi k D_l/N} = \sqrt{P_{\text{rx}}} X(k) H(k), \quad (3)$$

where $H(k)$ is the channel frequency response.

The baseband narrowband signal can be modeled as

$$s(n) = \sum_m a_m g(n - mT) \ , \quad (4)$$

where m is the symbol index, a_m denotes the mth data symbol, $g(n)$ is the pulse shaping filter with a roll-off factor α, and T is the symbol duration of the narrowband signal. In case of a CDMA signal, $s(n)$ becomes

$$s(n) = \sum_m a_m g(n - mT) p(n - mT) \ , \quad (5)$$

where $p(n)$ is the spreading chip sequence with R_{c} chips. Since $s(n)$ passes through a multipath channel $h'(l)$ with L_{nb} symbol-spaced taps[2], the received signal becomes

$$z(n) = \sqrt{P_{\text{rx}}} \sum_{l=0}^{L_{\text{nb}}-1} h'(l) s(n - lT) \ . \quad (6)$$

The discrete Fourier transform (DFT) of $z(n)$ will be denoted as $Z(k)$. The main lobe of the spectrum occupied by $Z(k)$ overlaps with K subcarriers of $Y(k)$ (see e.g., Fig. 1). Hence, if the center frequency of $Z(k)$ is located at subcarrier κ, the subcarriers $k \in \left[\kappa - \frac{K}{2}, \kappa + \frac{K}{2} - 1\right]$ will constitute the overlapping band (OB).

In time domain, NB symbols constitute structured information from a finite alphabet, while OFDMA signal behaves like random noise spread over multiple NB symbols. In frequency domain, on the other hand, OFDMA subcarriers carry structured information, and NB signal can be considered like random and colored noise covering multiple subcarriers. This is readily seen from the received signal, which can be denoted in time domain as

$$r(n) = \overbrace{z(n)}^{\text{NB}} + \underbrace{\overbrace{\sum_{k=0}^{N-1} Y(k) e^{j2\pi kn/N}}^{\text{OFDMA}}}_{y(n)} + w(n), \quad (7)$$

where $w(n)$ is the additive white Gaussian noise (AWGN) with a two sided power spectral density of $N_0/2$, and in frequency domain as

$$R(k) = \overbrace{Y(k)}^{\text{OFDMA}} + \underbrace{\overbrace{\frac{1}{N} \sum_{n=0}^{N-1} z(n) e^{-j2\pi kn/N}}^{\text{NB}}}_{Z(k)} + W(k), \quad (8)$$

where $W(k)$ is the frequency domain reciprocal $w(n)$.

III. Joint Demodulation Method

A well-known and efficient method for handling co-channel signals is to demodulate them jointly utilizing maximum likelihood estimation [12], [13]. For the coexistence scenario in consideration, ML estimation might be performed either in time or in frequency domain. However, time domain requires a smaller number of computations. This is due to the relationship between K and the number of NB symbols C, which can be written as $K = (1 + \alpha)C$, where α is usually greater than 0.

Denoting the estimates for the NB and OFDMA signals in time domain as $\hat{z}(n)$ and $\hat{y}(n)$, respectively, an ML estimate of both signals can be obtained as

$$\begin{aligned}\left[\hat{a}_m, \hat{X}(k)\right] &= \arg \min_{a_m, X(k)} \left\{ \left| r(mT) - z(mT) - y'(mT) \right|^2 \right\} \\ &= \arg \min_{a_m, X(k)} \left\{ \left| r(mT) - \sum_{l=0}^{L_{\text{nb}}-1} h'(l) a_{m-l} \right. \right. \\ &\qquad \left. \left. - \sum_{k=\kappa-\frac{K}{2}}^{\kappa+\frac{K}{2}-1} Y(k) e^{j2\pi kmT/N} \right|^2 \right\}, \quad (9)\end{aligned}$$

where $y'(n)$ is the time domain reciprocal of $Y(k)$ for $k \in \left[\kappa - \frac{K}{2}, \kappa + \frac{K}{2} - 1\right]$.

The number of different values that $z(mT)$ and $y'(mT)$ can take should be limited in order for the joint demodulation algorithm to be computationally feasible. This condition is satisfied for both $z(mT)$ and $y'(mT)$ since the data sequences a_m and $X(k)$ each belong to a finite alphabet. There are M^K possibilities for the OFDMA signal in the overlapping band, and M possibilities for each of the C symbols in the NB signal, where M is the number of constellation points depending on the modulation order (e.g., $M = 4$ for

[2]Note that the symbol-spaced equivalent of any physical channel can be obtained by convolving the actual channel impulse response with the pulse shaping filter employed and taking symbol-spaced samples.

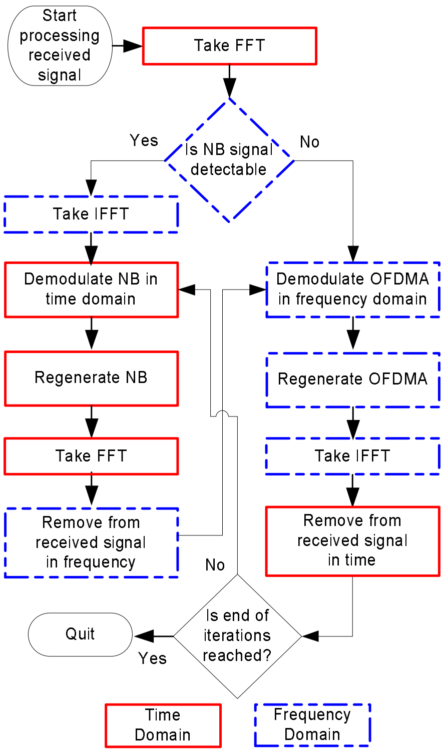

Fig. 2. Flowchart of the proposed iterative CCI cancellation algorithm.

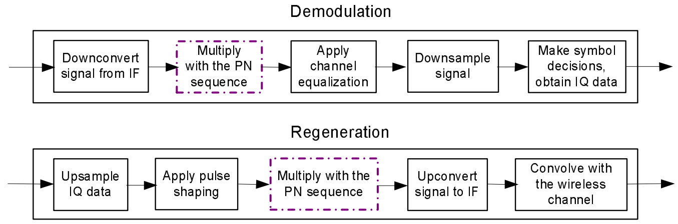

Fig. 3. Flowchart of the demodulation and regeneration modules for the NB system.

QPSK). Therefore, the number of possibilities that need to be considered for each NB symbol is M^{K+1}.

IV. Iterative CCI Cancellation Method

Due to the high complexity of the ML estimation based joint demodulation method, we propose an iterative CCI cancellation method as an efficient but low complexity alternative, which solves the CCI problem through enhancing both $Y(k)$ and $z(n)$ in a successive manner in multiple iterations.

The iterations get started by obtaining and using an initial estimate of either $z(n)$ or $Y(k)$, i.e. $\hat{z}(n)$ or $\hat{Y}(k)$, respectively. An initial rough estimation for $z(n)$ can be obtained utilizing $Z(k)$ if the power of $Z(k)$ is high enough that it can be sensed over the OB through energy detection. The threshold of the energy detector is set according to the average signal-to-noise ratio (SNR) level over $k \notin \left[\kappa - \frac{K}{2}, \kappa + \frac{K}{2} - 1\right]$. In case the number of subcarriers whose energy exceeds the threshold is close to K, an initial estimate for the NB signal is obtained by taking the IDFT of the subcarriers $k \in \left[\kappa - \frac{K}{2}, \kappa + \frac{K}{2} - 1\right]$ to yield

$$\hat{z}(n) = \sum_{k=\kappa-\frac{K}{2}}^{\kappa+\frac{K}{2}-1} R(k) e^{j2\pi kn/N}. \tag{10}$$

If the NB signal is too weak to provide a useful estimate, or if K is unknown, then, following an alternative approach, $R(k)$ is used as an initial estimate for $Y(k)$.

The main idea of the proposed method is to demodulate the estimated signal, $\hat{z}(n)$ or $\hat{Y}(k)$, and then to regenerate the signal waveform based on the symbol decisions made to obtain $\tilde{z}(n)$ or $\tilde{Y}(k)$. Note that $\tilde{z}(n)$ and $\tilde{Y}(k)$ are expected to be cleaner versions of $\hat{z}(n)$ and $\hat{Y}(k)$, respectively, since they are free of AWGN and supposedly less affected by CCI.

Since the initial estimate employed $\left(\hat{z}(n) \text{ or } \hat{Y}(k)\right)$ is corrupted by CCI and AWGN, the symbol decisions made may include errors. However, the effect of symbol errors made in $\hat{z}(n)$ is not localized in frequency domain; on the contrary, it is spread over K subcarriers. Similarly, a corrupted subcarrier in $\hat{Y}(k)$ has an impact that is spread over N samples in time domain. Hence, subtracting $\tilde{z}(n)$ with symbol errors from $r(n)$ does not necessarily corrupt subcarriers of $\hat{Y}(k)$. The same is true when $\tilde{Y}(k)$ with some incorrectly demodulated subcarriers is removed from $R(k)$; it does not necessarily lead to a $\hat{z}(n)$ with symbol errors.

The flowchart provided in Fig. 2 illustrates the steps that need to be followed after obtaining the initial signal. The first step is demodulation. The internal stages for demodulation are shown for the NB system in a separate flowchart in Fig. 3. It starts with downconverting the signal to the baseband from the intermediate frequency (IF) of $f_c' - f_c$, where f_c and f_c' are the carrier frequencies of the OFDMA signal and the NB signal, respectively. If the NB signal is a CDMA signal, this stage is followed by multiplication with the pseudo-noise (PN) sequence, which is shown with a dashed block in Fig. 3. The rest of demodulation is performed by applying channel equalization, downsampling, and making symbol decisions to obtain the IQ data. For the NB system, it is assumed that the carrier frequency f_c' is known, and a channel estimate $\hat{h}'(l)$ is available[3]. For the OFDMA system, downconversion and downsampling stages do not exist[4], and channel estimation is performed over pilot subcarriers to obtain $\hat{H}(k)$.

After obtaining the IQ data, regeneration (demonstrated for NB signal in Fig. 3) takes place. The steps that constitute regeneration are upsampling the IQ data, applying pulse shaping, (if the signal is a CDMA signal) multiplying the signal with the PN sequence, upconverting it, and convolving it with the baseband channel. Again, upsampling and upconversion are not performed for the OFDMA signal. The pulse shaping filter used by the NB system is assumed to be known. If the regenerated signal is $\tilde{z}(n)$, its DFT is taken, and the resulting signal $\tilde{Z}(k)$ is removed from $R(k)$ to obtain an estimate for the OFDMA signal, i.e.

$$\hat{Y}(k) = R(k) - \tilde{Z}(k) = R(k) - \frac{1}{N}\sum_{n=0}^{N-1} \tilde{z}(n) e^{-j2\pi kn/N}. \tag{11}$$

If the regenerated signal is $\tilde{Y}(k)$, its IDFT is taken, and the resulting signal $\tilde{y}(n)$ is subtracted from $r(n)$ to obtain an

[3]The proposed algorithm's performance for an NB system with channel estimation errors is investigated through simulations in Section V.

[4]The received signal $r(n)$ is already downconverted to the baseband based on the carrier frequency f_c of the OFDMA signal.

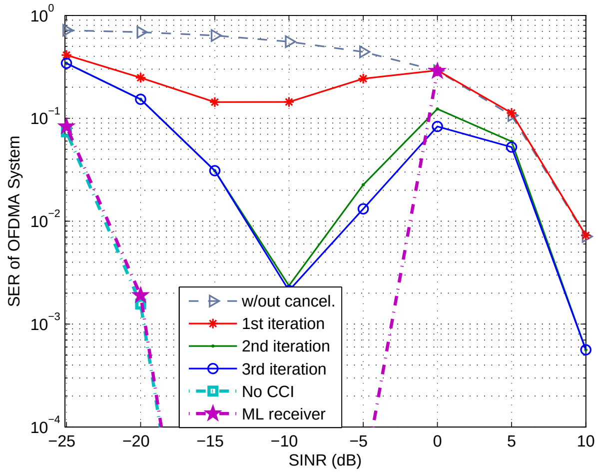

Fig. 4. SER performance of the OFDMA system under the influence of NB interference (AWGN channel).

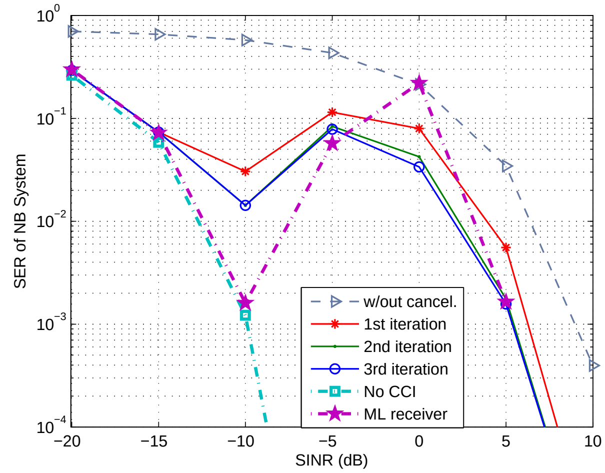

Fig. 5. SER performance of the NB system under the influence of OFDMA interference (AWGN channel).

estimate for the NB signal as follows

$$\hat{z}(n)=r(n)-\tilde{y}(n)=r(n)-\sum_{k=0}^{N-1}\tilde{Y}(k)e^{j2\pi kn/N}. \quad (12)$$

An important question that might be raised about the proposed method is why the entire OFDMA band is handled rather than dealing with the OB only, because processing the entire band has the following disadvantages:

- Since $\tilde{y}(n)$ is the IDFT of the entire OFDMA band rather than the OB only, any errors made in the demodulation of subcarriers $k \notin \left[\kappa-\frac{K}{2},\kappa+\frac{K}{2}-1\right]$ appear as additive noise in (12). It would be expected that this increases the number of NB demodulation errors, especially if K is small,
- The complexity of the algorithm becomes proportional to N rather than K.

The reasons why we do not deal with the OB only is that K may not always be known accurately, and also, subcarriers $k \notin \left[\kappa-\frac{K}{2},\kappa+\frac{K}{2}-1\right]$ might have been affected by the sidelobes of the NB signal. Moreover, through computer simulations, it is found that the extra noise caused by the demodulation errors outside the OB does not lead to a noticeable increase in the NB demodulation errors even for $\frac{K}{N}$ ratios as small as 2.5%.

V. Simulations

A. Simulation Parameters

Computer simulations are done to determine the performance of the proposed iterative canceler in different scenarios as well as to compare it with the joint demodulation method's performance. Main simulation parameters used are presented in Table I. The OFDMA symbol occupies 400 subcarriers out of 512 available ones due to the guard bands and empty subcarriers. The overlapping band, which is located in the middle of the OFDMA spectrum, is approximately 40 subcarriers wide for the NB signal, and 128 subcarriers wide for the uplink CDMA signal.

The SER performances of OFDMA, NB, and CDMA systems are investigated both in AWGN (Figs. 4-5) and multipath (MP) (Figs. 6-9) channels. In MP simulations, availability of a perfect channel estimation is assumed for NB and CDMA,

TABLE I
OFDMA, Narrowband, and CDMA System Parameters

Parameter	OFDMA	Narrowband	CDMA
Bandwidth	5 MHz	370 kHz	625 kHz
Samples per symbol	512	16	32
Modulation	QPSK	QPSK	QPSK
MP channel model	Veh. A	Out.-to-in. A	Out.-to-in. A
Pulse shape	Rectang.	Raised cos. (α=0.3)	Raised cos. (α=0.3)

and an efficient maximum likelihood sequence estimation (MLSE) equalizer is utilized. For OFDMA, on the other hand, pilot based practical channel estimation and equalization are performed. In all simulations, while the desired signal power is varied over a certain range, noise power is fixed, and interference SNR is kept constant. Signal-to-interference-plus-noise ratio (SINR) is defined as the ratio of the desired signal power to the sum of interference and noise power over the overlapping band.

In Figs. 4-9, the uppermost curve shows the performance obtained without cancellation (w/o-C), whereas the lowest curve shows the performance when CCI does not exist (no-CCI). The three curves in between demonstrate the SER performances after each iteration[5]. The SINR values on the x-axis apply only to the w/o-C curve. As a last note, the no-CCI curve is actually an SER vs. SNR curve shifted leftwards by the amount of interference SNR, which is 30 dB in Fig. 4 and Fig. 6; 25 dB in Fig. 7; 20 dB in Fig. 5 and Fig. 8; and 15 dB in Fig. 9.

B. Simulation Results

Fig. 4 shows the SER performance of the OFDMA system interfered by an NB system. At very low SINR, since the interference can be detected accurately, the gain with respect to w/o-C can be as large as 25 dB after the 3rd iteration. As SINR approaches 0 dB, however, it becomes challenging to separate the two signals, and the gain drops to around 6 dB. Beyond 10 dB SINR, the SER curve of the proposed method approaches to the w/o-C curve. Another performance curve

[5] In Fig. 8, the first two iterations are omitted, and the performance curves obtained for two different channel estimation error levels are displayed instead.

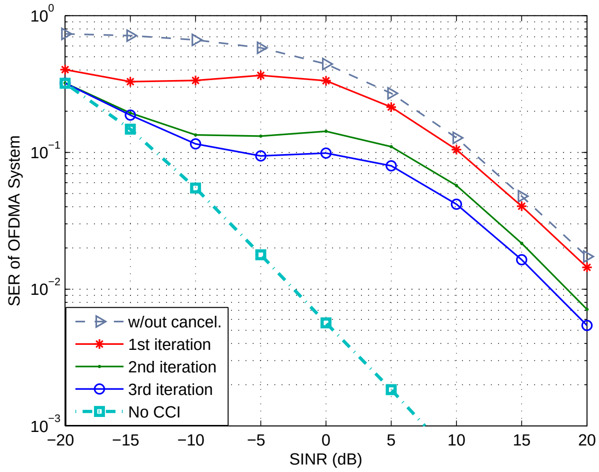

Fig. 6. SER performance of the OFDMA system under the influence of NB interference (MP channel).

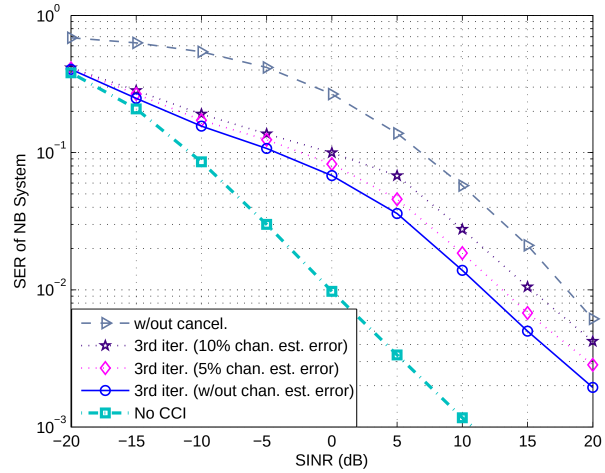

Fig. 8. SER performance of the NB system under the influence of OFDMA interference (MP channel).

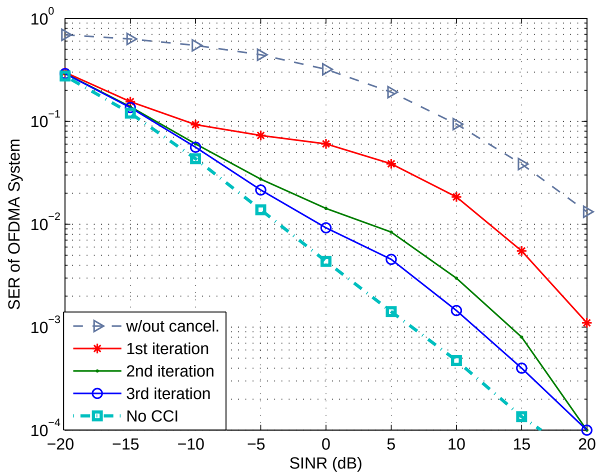

Fig. 7. SER performance of the OFDMA system under the influence of CDMA interference (MP channel).

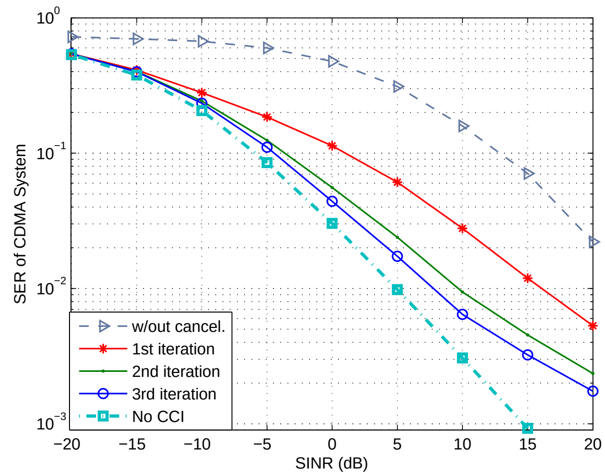

Fig. 9. SER performance of the CDMA system under the influence of OFDMA interference (MP channel).

displayed in Fig. 4 belongs to the ML receiver, whose SER is as low as the no-CCI case at low SINR values. The ML receiver is superior to the iterative canceler everywhere except around 0 dB SINR, where ML is known to have demodulation problems in AWGN channels [9].

The NB system performance improvement enabled by the proposed method is shown in Fig. 5. For SINR values smaller than 0 dB, the gain with respect to no-CCI can be as high as 18 dB. For SINR greater than 0 dB, there is still a gain around 3 dB. Fig. 5 also shows the ML receiver performance. ML receiver is superior to the iterative canceler in general except around 0 dB SINR.

In MP simulations in Figs. 6-9, the margin between w/o-C and no-CCI curves is not as wide as in the AWGN case. Nevertheless, the proposed algorithm is still able to provide considerable gains. For the OFDMA system interfered by the NB signal (Fig. 6), the gain is above 15 dB up until 0 dB SINR, after which it decreases towards 5 dB again. When the interferer is CDMA (Fig. 7), on the other hand, the gains are considerably higher, and the performance approaches the no-CCI case. The reason for this performance difference is the involvement of the PN sequence, which introduces additional signal separability. The fact that the CDMA signal power is spread over a wider frequency band makes the OFDMA signal more accurately detectable.

Improvement of the NB performance is shown in Fig. 8. The gain obtained for SINR smaller than 0 dB is more than 12 dB. Approaching 0 dB SINR, this gain becomes smaller, but even at 10 dB SINR there is still a gain of approximately 5 dB. Impact of NB channel estimation error on the performance of iterative cancellation is also demonstrated in Fig. 8. The variance of the Gaussian noise added to each channel tap estimate is set as a certain ratio of the power of that tap. The two ratios examined are 5% and 10%. It is observed that the cancellation gain decreases with increasing channel estimation error. Still, it can be stated that channel estimation errors, which are likely to occur under CCI effect, do not have a very strong influence at error levels as large as 5%.

The CDMA performance improvement (see Fig. 9) is more

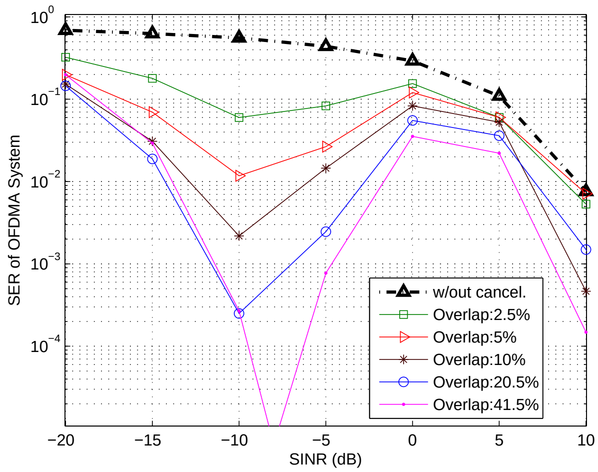

Fig. 10. OFDMA system's SER performance under the influence of NB interference for various overlapping bandwidths (AWGN channel).

critical. The performance is almost as good as no-CCI case up until 0 dB SINR, after where it starts to decrease. The difference between the NB and CDMA curves' behavior is again thanks to the use of a PN sequence.

The width of the OB has a considerable effect on the cancellation performance. This effect is investigated in terms of SER values of the OFDMA system in Fig. 10, where the OBs are expressed as their ratio to the OFDMA bandwidth. The performance curves obtained for various overlap percentages clearly indicate that increasing overlap leads to a more successful cancellation. This is because, for a given SINR value, the energy of the NB signal changes linearly depending on its bandwidth, i.e. the NB signal in a widest overlap scenario is the strongest one. Increased NB signal energy leads to a more successful demodulation of the NB symbols, which in turn boosts the overall performance of the algorithm.

Finally, a numerical comparison of complexities of iterative cancellation and ML algorithms is provided in Table II in terms of CPU cycle counts (a Xilinx DSP48 slice is considered where the cycle numbers for ADD, MUL, and CMP operations are 1, 3, and 1, respectively [14]). Cycle counts determined for various sets of system parameters are demonstrated, where Iter. I stands for the iterative cancellation method employing an MLSE equalizer for the NB system, and Iter. II is the iterative method employing a linear equalizer (LE). A drastic difference is seen between the cycle numbers required for ML and Iter. I algorithms. This is because every step of the ML estimation has an exponential complexity, whereas Iter. I has a linear complexity except for the MLSE equalizer that it employs. Cycle counts for Iter. II algorithm show that the complexity of the iterative cancellation can be decreased further by employing an LE, especially when M or L is large.

It is seen that parameter K (and C, which depends on K) acts exponentially on the complexity of ML estimation and linearly on the iterative cancellation. M affects ML estimation and Iter. I exponentially, whereas it has a negligible effect on Iter. II. N has a linear effect on all algorithms, and $\mathcal{I}$ has a linear effect on the iterative ones. L has a relatively weak impact on ML estimation and Iter. II, whereas it affects Iter. I exponentially.

TABLE II
CPU CYCLE COUNTS OBTAINED USING A XILINX DSP48 SLICE

N	K	C	L	M	$\mathcal{I}$	ML	Iter. I	Iter. II
512	40	32	4	4	3	5.3×10^{28}	2.3×10^{6}	7.9×10^{5}
512	20	16	4	4	3	4.7×10^{16}	1.3×10^{6}	5.8×10^{5}
512	10	8	4	4	3	4.4×10^{10}	8.6×10^{5}	4.8×10^{5}
512	40	32	4	16	3	7.0×10^{52}	3.9×10^{8}	7.9×10^{5}
512	40	32	4	4	5	5.3×10^{28}	3.8×10^{6}	1.3×10^{6}
512	40	32	1	4	3	5.3×10^{28}	7.8×10^{5}	7.8×10^{5}
1024	40	32	4	4	3	1.1×10^{29}	3.2×10^{6}	1.6×10^{6}

VI. CONCLUDING REMARKS

In this paper, an iterative CCI canceler is proposed and related application scenarios are provided. It is shown that processing the whole MC band rather than only the overlapping band is more advantageous in spite of the increased complexity. Moreover, it is numerically demonstrated that the proposed method is significantly less complex than joint demodulation. In the simulations, fundamental gains are obtained for both co-channel signals in terms of SER performance validating the claimed efficiency of the proposed method. Also, the effect of NB channel estimation errors on the available gains is quantified. Finally, it is found that larger gains are possible when the overlap between the NB and MC signals is larger.

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