

Analyzing the Co-Existence of LTE-A Signals in Heterogeneous Network Model

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ABSTRACT: The main aim is to introduce new degree of freedom for the efficient reuse between two co - existence signals. The co-existence is first done for the Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier – Frequency Division Multiple Access (SC-FDMA) signals. As a baseline their average bit error rate and the bit error rate with and without frequency offset would be calculated. This process is analysed using conventional successive interference cancellation processing(c-SIC).Then it leads to the improved multi user detection approach (MUD). At last the throughput is calculated for the co-existing signals. Due to reused co-existing signals the throughput calculated will be high.

KEYWORDS: Co-existence, Successive interference cancellation, Orthogonal frequency division multiple access (OFDMA), Single carrier-frequency division multiple access (SC-FDMA), Heterogeneous network.

I. INTRODUCTION

Heterogeneous networks (HetNets) are a solution to offload the macrocell traffic and increase the multiple accessing capabilities of the network. Wireless services enabled advanced applications and these services are spreading like wildfire between users. There are orthogonal multiple accessing (OMA) and non-orthogonal multiple accessing (NOMA) schemes. OMA schemes for homogeneous networks hold mobile stations (MSs) that are claiming access to the network until the RBs are released by other MSs. In the NOMA schemes RBs are allocated to the MSs non-orthogonally and co-channel interference occur.

The main of this network is to bring new degree of freedom with the help of NOMA schemes by introducing co-existence between OFDMA and SC-FDMA signals. The receiver used for this co-existence of signals is the conventional successive interference cancellation receiver. First as a baseline average bit error rate would be calculated and then the bit error rate for both the signals would be calculated with and without the frequency offset. To improve the receiver performance the c-SIC would be replaced with and better performing approach which the multi user detection approach. The throughput calculated for this performance would be better throughput value.

II. RELATED WORK

These NOMA schemes are also used for another class studied to review their solutions. So the resource blocks are allocated non-orthogonally and co channel interference would occur. So these approaches are employed to a new detection approaches so that the interference in the receiver is removed [1]. There are many approaches one of them is the cell range expansion, where the time domain of the resources are shared by the small cell basestation and the macrocell basestation with use of the blank frames [7]. There are advantages in using NOMA schemes where the enhanced fairness used between many users can increase the cell-edge throughput[2] [6].

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III. SYSTEM MODEL

In this network model the number of subcarriers NS would be 512. There are two user's user k and user m . Normally the basic OFDMA process would be done in which the inverse discrete Fourier transform (IDFT) would be done for the subcarrier and after adding the cyclic prefix they would be transmitted in the wireless channel which will be the AWGN channel.

A. Homogeneous Network Model

The subcarrier of the received composite signal of user m and user k at the BS is

$$Y_n = \sqrt{p_{m,n}}x_{m,n}h_{m,n} + \sqrt{p_{k,n}}x_{k,n}h_{k,n} + \eta_n \quad (1)$$

where $p_{m,n}$ and $p_{k,n}$ are the received powers, $h_{m,n}$ and $h_{k,n}$ are the channel frequency responses of the two user's signals m and k , and η_n is the independent and identically distributed complex additive white Gaussian noise (AWGN) with σ_η^2 variance at the n^{th} subcarrier. Thus the powers of the transmitted signals can be tuned for the MSs considering the characteristics of the wireless channel.

B. Heterogeneous network model

In this network model the timing for the different signals to reach the base station becomes complicated. However at the receiver there would be interference due to misalignment. Therefore to avoid the misalignment the cyclic prefix value should be doubled. Thus these co-existing signals are analysed using these system models.

IV. PROPOSED ANALYZED METHODS

These co-existence signals are first analysed for their bit error rate with frequency offset and without frequency offset. Secondly the interference for the OFDMA signals and the SC-FDMA signals are also analysed. These all analysing process are done with the c-SIC receiver. To improve this method a design of MUD is used in the receiver section.

A. Bit error rate with and without frequency offset

Here the interference of user k is larger than the interference of user m . Therefore the user k is decoded first. This is the equalization for user k

$$\beta_{k,n} = x_{k,n} + x_{m,n} \Phi_{m,n} + \hat{\eta}_{k,n} \quad (2)$$

Where the value of $\Phi_{m,n} = \sqrt{\frac{p_{m,n} h_{m,n}}{p_{k,n} h_{k,n}}}$ and $\hat{\eta}_{k,n} = \frac{\eta_n}{\sqrt{p_{k,n} h_{k,n}}}$. After decoding the signals are retransmitted to the receiver section. The equalization for the user m is the inverse of the user k which is $\Phi_{k,n} = \Phi_{m,n}^{-1}$.

$$\beta_{m,n} = x_{m,n} + x_{k,n} - \hat{x}_{k,n} \Phi_{k,n} + \hat{\eta}_{m,n} \quad (3)$$

This is the equalization for user m and the value of $\hat{\eta}_{m,n} = \frac{\eta_n}{\sqrt{p_{m,n} h_{m,n}}}$. Thus user k is first decoded the BER of user m would be affected by user k errors. Thus the BER would be calculated in pairs.

B. calculating the interference of the signals

From the analysis the subcarriers of user m and k are the symbols of user m and k respectively. Therefore the error of user k due to user m is given as

$$\xi_{k,n} = s_{m,n} \Phi_{m,n} \quad (4)$$

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In the same way the error of user m due to user k is given as

$$\xi_{m,n} = (s_{k,n} - \hat{s}_{k,n})\phi_{k,n} \quad (5)$$

Here the user m's error disappears. The error in equation (4) and (5) are mainly affected by the power of the receiver and the modulation used for these signals.

$$\xi_{k,n} = x_{m,n} * \phi_{m,n} \quad (6)$$

In the other case user k would be OFDMA and user m would be SC-FDMA. Here all the symbols of user m would be an error. This is because of the Discrete Fourier transform (DFT). Then the error rate of user k at this point is given as

$$\xi_{k,n} = \frac{\phi_{m,n}}{\sqrt{N_m}} \sum_{l=0}^{N_m-1} s_{m,l} e^{-j2\pi l(n-m_1)/N_m} \quad (7)$$

Therefore the error rate of nth symbol of the user k would the sum of the value of nth subcarrier of user k.

In this case the signal of user m is obtained by the c-SIC process. The error rate of user m's symbol is given as

$$\xi_{m,l} = \frac{1}{\sqrt{N_m}} \sum_{n=n_1}^{n_2} (s_{k,n} - \hat{s}_{k,n})\phi_{k,n} e^{j2\pi l(n-m_1)/N_m} \quad (8)$$

$$\xi_{m,l} = (s_{k,n} - \hat{s}_{k,n})p_{k,n} \quad (9)$$

C. Conventional successive interference cancellation (c-SIC)

The error calculation of the co-existence signals helps us to find out the SINR of these signals. Thus the SINR of the user k is found out with the non-overlapping and the co-existing subcarriers, which is given as

$$\gamma_k = \sum_{\substack{n=k_1 \\ n \notin [n_1, n_2]}}^{k_2} \frac{p_{m,n}}{\sigma_\eta^2} + \sum_{n=n_1}^{n_2} \frac{p_{k,n}}{p_{m,n} + \sigma_\eta^2} \quad (10)$$

In the same way the SINR of user m is found out with the non-overlapping and the co-existing subcarrier, which is also given as

$$\gamma_m = \sum_{\substack{n=m_1 \\ n \notin [n_1, n_2]}}^{m_2} \frac{p_{m,n}}{\sigma_\eta^2} + \sum_{n=n_1}^{n_2} \frac{p_{m,n}}{p_{k,n} |x_{k,n} - \hat{x}_{k,n}|^2 + \sigma_\eta^2} \quad (11)$$

The SINR of the user is given as the weighted sum of the bit error rate of non-overlapping and co-existing subcarriers as

$$P_{r_u} = \frac{N_{D,u}}{N_u} P_{r_{D,u}} + \frac{N_{x,u}}{N_u} P_{r_{x,u}} \quad (12)$$

The BER of the co-existing symbols of user k is changed with the ratio of the power received by the receiver. So the terms are contributed with the probability of error and are integrated with the Marcum Q-function. The BER of the user k's signal is given as

$$P_{r_{D,k}} = Q \left(\sqrt{\frac{p^k}{\sigma_\eta^2}} \right) \quad (13)$$

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$$P_{r_{x,k}} = \frac{1}{N_c} \sum_C Q \left(\sqrt{\frac{|p_k c_k + p_m c_m|}{\sigma_\eta^2}} \right) \quad (14)$$

$$P_{r_k} = \frac{N_k - N_o}{N_k} P_{r_{D,k}} + \frac{N_o}{N_k} P_{r_{x,k}} \quad (15)$$

In the same way the user m are also analysed with the c-SIC processing. The terms of user m are contributed with the probability of error and also integrated with the Marcum Q-function. Thus the BER of user m's signal is given as

$$P_{r_{D,m}} = Q \left(\sqrt{\frac{p_m}{\sigma_\eta^2}} \right) \quad (16)$$

$$P_{r_m} = \frac{N_o}{N_m} (P_{r_{x,k}} + (1 - P_{r_{x,k}})P_{r_{D,m}}) + \frac{N_m - N_o}{N_m} P_{r_{D,m}} \quad (17)$$

D. Maximum Likelihood – Successive interference cancellation (ML-SIC) receiver

First the co-existence of the signals are analysed with c-SIC receiver for the error terms without frequency offset. Also the SINR of the symbols which are far away from the overlapping subcarrier is larger than the one which are closer. But the c-SIC does not takes this into consideration and decodes the symbol even though with the larger SINR. In this section if we replace the c-SIC with ML-SIC it takes the SINR into consideration and decodes the symbol with smaller SINR.

V. SIMULATION RESULTS

A. BER results of OFDMA and SC-FDMA

First the BER are analysed for the co-existence signals OFDMA (MC) and SC-FDMA (SC) based on both the c-SIC and ML-SIC receivers. The user m and user k signals are allotted with 512 subcarriers with a total of 1024 subcarriers. These signals are analysed with different comparison schemes.

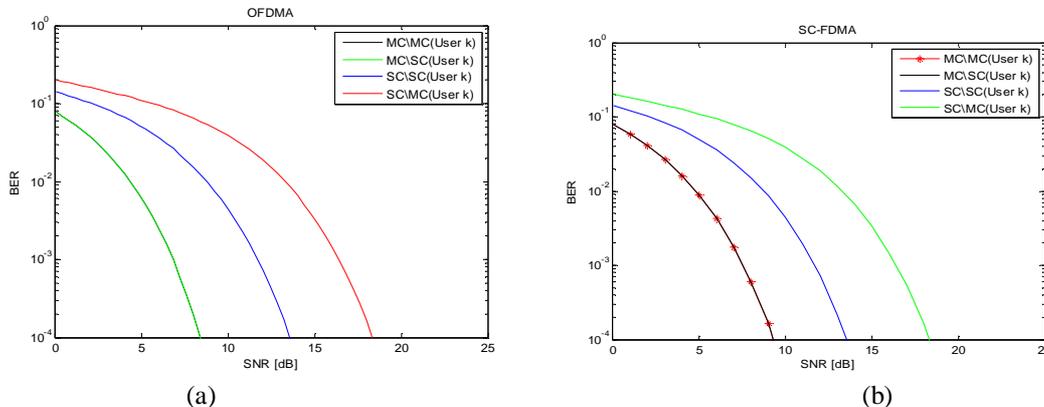


Figure (a) Shows the BER of OFDMA signals and (b) Shows the BER of SC-FDMA signals. In this performance the ratio of BER and SNR of both the users as SC or MC has the good and poor BER graph respectively. But the performance of co-existence of SC/MC is better than the co-existence of MC/SC.

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B. BER performance with and without frequency offset

In these results the BER performance of frequency offset is shown with c-SIC receiver. A frequency offset of $f_0 = 0.5$ with a overlapping ratio of $\frac{1}{2}$ is introduced between these co-existing signals.

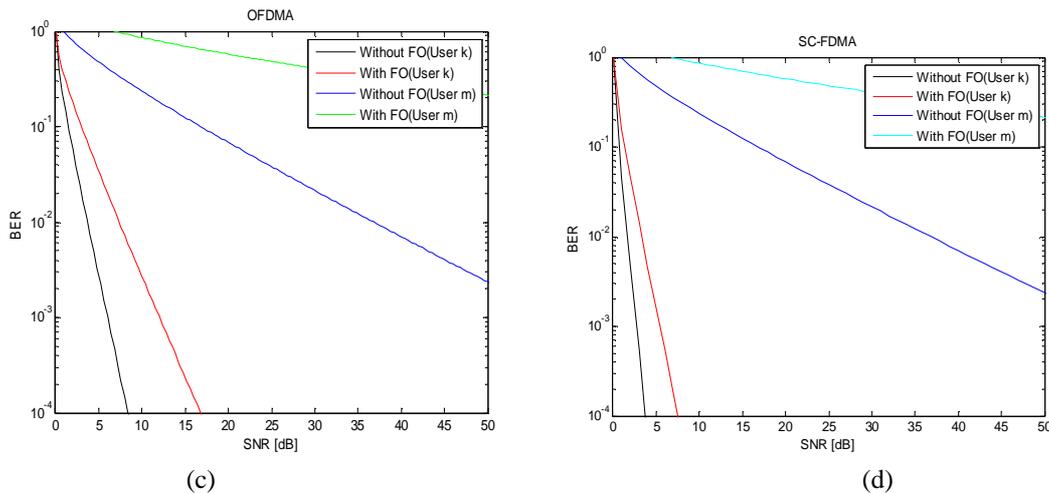


Figure (c) Shows the BER performance of OFDMA signal with and without frequency offset and (d) Shows the BER performance of SC-FDMA signals with and without frequency offset. The BER with f_0 frequency offset of the user's signals is compared without f_0 frequency offset. Here the co-existence of BER of the same signals has the worst BER compared to that without the frequency offset.

C. Hexagonal plot

This performance is done for both homogeneous and heterogeneous network model. Where the macro base station and macro mobile station are plotted on a hexagonal grid model.

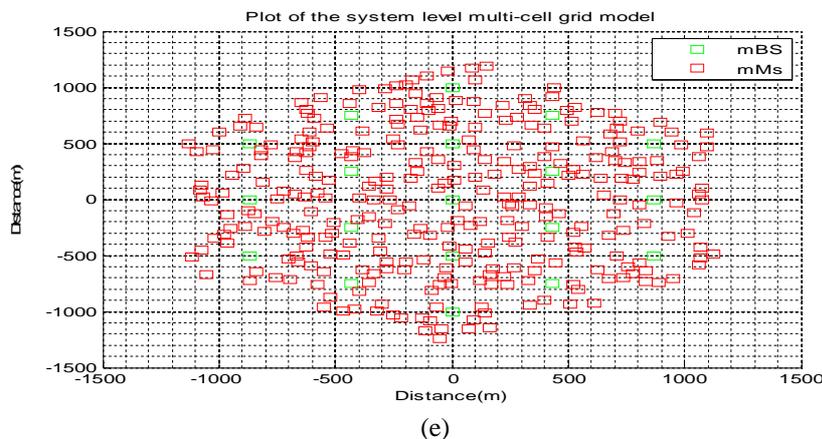


Figure (e) Shows the Hexagonal multi cell grid model plot of BS and MS. There are 19 base station and many mobile station surrounding each of the base station. There are 512 subcarriers for each of mobile stations and 25 resource blocks are allocated and the rest is left as guard band. The modulation used for these switching stations is QPSK and QAM.

D. Throughput of ODMA and SC-FDMA

The throughput (CDF) is calculated based on the symbol error rates. This below graph shows the throughput comparisons for OFDMA and SC-FDMA signals.

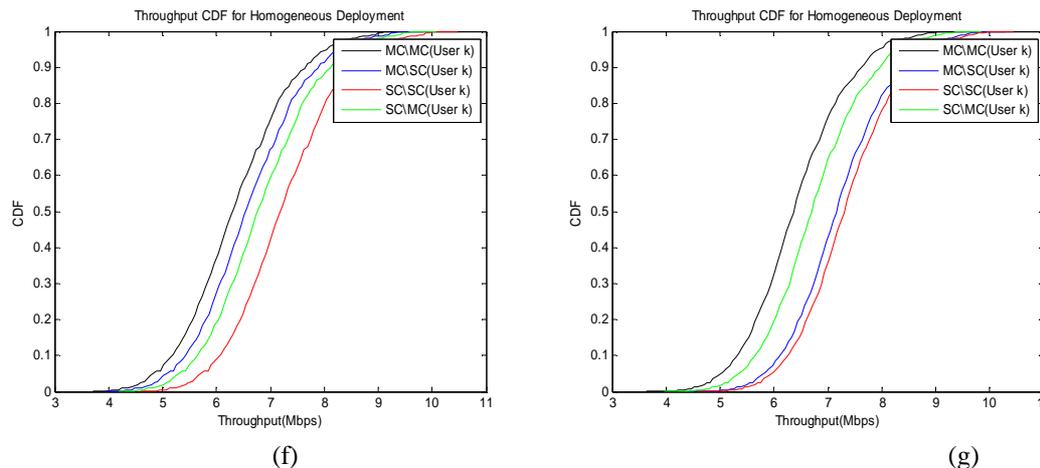


Figure (f) Shows the throughput of OFDMA signal and (g) Shows the throughput of SC-FDMA signal. The co-existence with the best selected results provides 20% gain in 90% throughput.

VI. CONCLUSION

The analysed methods provide another degree of freedom for the interferences in the LTE-A network models. These methods provide better throughput for the system. Even though these systems can be further improved by introducing Minimum mean square error (MMSE) equalization receiver which would even more better performance by reducing the interference in the system. Instead of AWGN channel Rayleigh channel can also be used to improve the performance of the system.

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