

Analysis of Resource Allocation in Wireless Networks with Inter-Cell Interference Reduction

G.Kumaran¹, G.Sangeethapriya², J.Suganya³Associate Professor, Department of Electronics and Communication Engineering, SKP Engineering College
Tiruvannamalai, Tamilnadu, India¹Assistant Professor, Department of Electronics and Communication Engineering, SKP Engineering College
Tiruvannamalai, Tamilnadu, India^{2,3}

ABSTRACT: The Resource allocation in cellular networks using orthogonal frequency division multiple access (OFDMA) systems. Both center cell and edge cell users using same power, edge cell users suffer for Inter Cell Interference (ICI). Power allocation cell-edge user's power is maximized automatically reduce the inter cell interference under the condition that desirable performance for cell-center users must be maintained. Node B (Base Station) coordinate with each other Node in power allocation. The power optimization is formulated as a Greedy Power allocation method. Simulation results indicate that our proposed scheme can achieve significantly balanced performance enhancement between cell-edge and cell-center users in multi-cell networks, and goal of future wireless networks in terms of provided that high performance to everyone from everywhere.

I. INTRODUCTION

The NEXT generation wireless cellular networks objective global high data rates, efficient resource (e.g., spectrum and power) usage and inexpensive network distribution. Given the fact that radio spectrum is becoming a unusual resource in wireless Communications, the orthogonal frequency division multiple access (OFDMA) has been suggested as a state-of-the-art air interface technology to enable high spectrum efficiency and effectively conflict frequency-selective fading. Due to its promising features, OFDMA is accepted in many emerging cellular systems in Inter cell Interference and power allocation and frequency reuse for achieving those ambitious objectives of next generation networks.

In order to recognize the give on access of radio resources, OFDMA positions a new challenge for radio resource management (RRM). A good RRM scheme, including subcarrier allocation, scheduling and power control, is crucial to promise high system performance for OFDMA-based networks. On traditional design of RRM, most published work concentrate on the single-cell scenario where resources are allocated to deliver a local performance optimization. In future wireless networks, however, denser cellular deployment with a lower frequency reuse factor is demanded. This has moved the trend to the development of RRM for multicell systems. In the multi-cell context, inter-cell interference (ICI) has become a major issue of concern since the frequency reuse-1 is agreed as the preferred frequency planning deployment for modern OFDMA-based cellular networks. Due to the same spectral usage in adjacent cells, ICI can result in severe performance degradation to users of reuse-1 OFDMA networks, particularly those at the cell edge.

Thus, emerging RRM schemes with an importance on ICI Reduction in the multicell scenario is of important interest to recent research work. The ICI-aware RRM in multi-cell OFDMA networks, in general, can be formulated as a global performance optimization problem by considering the signal-to-interference-and noise ratio (SINR) instead of the signal-to-noise ratio (SNR). Unfortunately, finding the optimal solution to such a global optimization problem is extremely hard and normally not applicable in practice. This is because the problem has been known as a mixed integer programming (MIP) and proven to be NP-hard, which is computationally prohibitive to attack. Thus, in literatures this work has been analyzed from different standpoints and consequently can be separated into three categories.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

The first method aims at randomizing the interfering signal and thus allowing interference suppression at the mobile terminal either by applying (pseudo) random scrambling after channel coding/interleaving or using different kinds of frequency hopping.

The second method based on interference suppression which can be achieved by spatial suppression using multiple antennas at the mobile terminal and Node .

The last method aims at applying conditions to the downlink resource management in a coordinated way between cells. These conditions can be either on the available resources of the resource manager or can be in the form of limitations on the transmit power that can be applied to certain radio resources. Such conditions in a cell will provide the possibility for improvement in SINR, and constantly to the cell edge throughput and coverage. Inter-cell Interference Co-ordination (ICIC) requires also communication between different network nodes in order to set and reconfigure these conditions. Two cases are considered, the static one where reconfiguration of the conditions is done on a time scale conforming to days and the semi-static where the time scale is much smaller and corresponds to seconds.

The impact of inter-cell interference is more obvious for the cell-edge users, which are more sensitive due to the already bad channel gains with their serving base stations. This results in poor receptions at the cell edge in the downlink direction. Limited reception at the cell edge is an issue of great importance for the wireless operators who want to provide full coverage inside their service area and promise a certain Quality of Service (QoS) to their subscribers independently of their positions inside a cell. The recent discussions in the LTE project about inter-cell interference modification techniques shows the strong interest and will of the wireless industry to study and overcome this problem.

The scope of this thesis is to examine how users can share the available radio resources, in terms of bandwidth and power allocation, in order to suppress inter-cell interference and enhance cell-edge throughput and spectrum efficiency. The performance of the proposed schemes is examined comprehensively in a multi-cell network. The schemes are also evaluated under different situations with respect to uneven user distribution and various traffic loads. Extensive simulations establish that the proposed schemes can provide significant performance enhancement for both cell-edge and cell-center users compared with existing schemes. It is also shown that substantial fairness can be further addressed by the proposed schemes in terms of achieving balanced performance between cell-edge and cell-center users in the network.

II. SYSTEM MODEL

A Multi-user OFDMA-based downlink network is considered in this project. One example of the network layout with seven hexagonal cells is displayed in Fig: 1, where a BS equipped with an omnidirectional antenna is placed at the center of each cell to serve users who are randomly distributed within the cell. In OFDMA systems, the frequency resource is divided into subcarriers while the time resource is divided into time slots. The smallest radio resource unit that can be allocated to transport data in each transmission time is termed as traffic bearer in general. The PRB is a group of subcarriers that can be coherently allocated to users in a given time. For consistency, thus, from now on we will use the term PRB to As specified in the LTE standard, the traffic bearer is defined as a physical resource block (PRB), which consists of twelve consecutive subcarriers in the frequency domain and one slot duration (0.5 msec) in the time domain represent the single unit of radio resource for allocation in the OFDMA-based network. In addition, the following fundamental norms are made throughout the remainder of this paper.

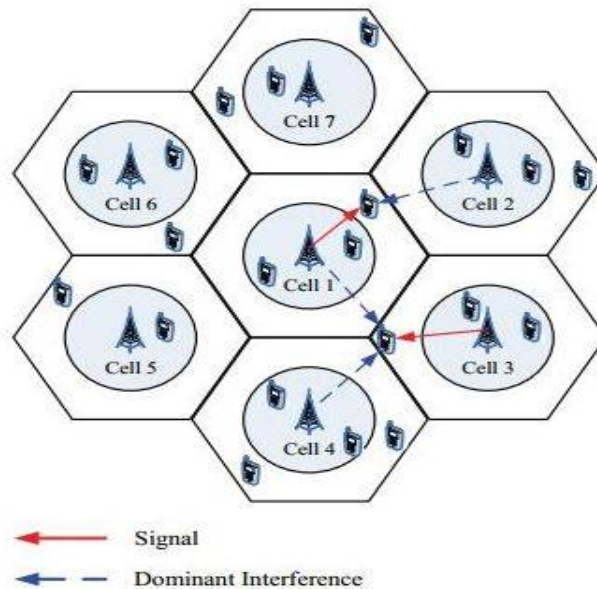
1. In each cell, users are categorized as either cell center or cell-edge users depending on their current geographic locations and straight-line distances to the serving BS. The boundary that separates the cell center and cell edge area, can be adjusted as a design parameter. The geographic location information can be reported to the BS by users periodically via the uplink control channels.

2. In every transmission time interval (TTI), each BS has to make a decision on PRB assignment to its served users. The duration of TTI is equal to one time slot of the PRB. We also assume that BSs can have perfect knowledge of channel state information updated periodically via feedback channels for every TTI.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015



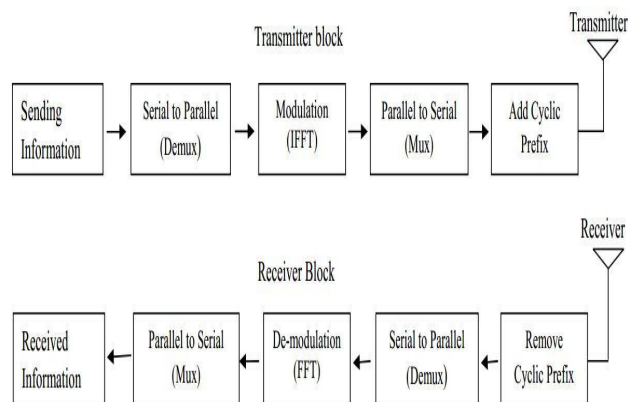
An Example of LTE cellular Network with inter cell interference

3. The transmission power is allowed to be independently allocated on each active PRB that has been assigned to users in the network. Hence, dynamic or fixed power allocation can be performed depending on different given schemes. The sum of the overall allocated power in each cell cannot exceed the maximum transmission power of the BS. We assume that all BSs in the network are given the same maximum transmission power.

4. To any cell, only interference from its adjacent

Cells are regarded as the effective ICI. In particular, to any cell-edge user there is a dominate interference that usually comes from its closest adjacent cell. In addition, cell-edge users may have at most two dominant interfering cells when they are located at the corner of serving cells and thus have nearly equal distances with both neighboring cells. Note that this assumption has been invoked by many prior authors in literature and particularly verified.

OFDM Block Diagram



The OFDM Transmitter information is Demultiplexing in serial to parallel converted and applied to the modulation in IFFT. the IFFT operation in information is converted to samples and again multiplexing operation is performed. The

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

modulated information adding to cyclic prefix use of interference avoidance, that information is sent to transmitting in wireless medium. Again Receiver side reverse operation is performed.

III. PROBLEM FORMULATION

Optimization goal is to maximize the overall throughput of cell-edge users while maintaining the required throughput for cell-center users. As a result, a balanced performance improvement between cell edge and cell-center users is expected to be achieved in the multi-cell systems. The reason behind this is that cell-center users usually do not suffer from heavy ICI and relatively high performance is easy to be obtained for these users even in a network without optimization, whereas cell-edge users' performance is much more vulnerable to ICI and their performance improvement has to strongly rely on optimization schemes.

Cell-edge users suffer from severe interference due to the shorter distances to the adjacent BSs.

1. Users within the same cell are mutually connected.
2. For any cell-edge user, the connection is only pair wise established with other cell-edge users of its dominant interfering cells.

a. MULTIPLE-ACCESS INTERFERENCE

The Sum of interference caused by other user operating within the same cell (intra cell interference) and the interference caused at the mobile user in a cell due to reuse of same channel in the neighboring cells (inter cell interference).

$$I_{MAI} = I_{intra} + I_{inter}$$

Fig depicts intracell and intercell interference in hexagonal cells

$$I_{intra} = \left(\frac{M}{Q}\right) * E_b$$

Where M is the number of simultaneous users, Q is number of chips per time period, and E_b is the common received power level. Where $\left(\frac{M}{Q}\right)$ is channel capacity.

b. INTERCELL INTERFERENCE FACTOR

The relative Intercell interference factor is ratio of Intercell interference and intracell interference. that is

$$\sigma = \frac{I_{inter}}{I_{intra}}$$

The value of σ ranges from 0.5 to 20, depending upon operating environmental conditions.

$$I_{MAI} = (1 + \sigma) \left[\left(\frac{M}{Q}\right) * E_b\right]$$

Thus, the MAI is directly proportional to the channel capacity, M/Q

c. SIGNAL TO INTERFERENCE NOISE RATIO (SINR)

SINR at the individual receiver is given by

$$SINR = \frac{E_b}{N_0 + I_{MAI}}$$

CDMA cellular systems are often interference limited; that is the operating conditions are such that

$I_{MAI} > N_0$ (typically 6 to 10dB higher).

$$SINR = \frac{1}{(1 + \sigma) \left(\frac{M}{Q}\right) \left(\frac{N_0}{I_{MAI}} + 1\right)}$$

This expression shows

- Intercell interference, σ . It depends on the environment as well as on the handover technique

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

- The channel capacity, $\left(\frac{M}{F}\right)$: It is a design parameter that needs to be maximized in a commercial cellular system.
- The operating I_{MAI}/N_0 . It related to cell size

IV. POWER ALLOCATION APPROACH

The radio resource allocation, the power allocation is decided individually in each cell and subsequently performed by BSs in a distributed manner. Therefore, a distributed power allocation approach is proposed in this section with an emphasis on performance optimization for cell-edge users.

a. TOTAL POWER DISTRIBUTION

The overall transmission power of each cell into two parts: total power for cell-edge users and cell-center users. Let P_E^j and P_C^j denote the total power allocated to cell edge users and cell-center users in cell j, respectively, and $P_E^j + P_C^j = P_{MAX}$. Note that Pmax is assumed to be the same for all BSs in the network.

$$P_E^j + P_C^j = P_{MAX}$$

$$\frac{P_E^j}{P_C^j} = \alpha \frac{|B_C^j|}{|B_E^j|}$$

Where B_C^j and B_E^j denote sets of total PRBs occupied by cell-center and cell-edge users in cell j, respectively, and α ($0 < \alpha < 1$) is a proportional factor indicating that a higher weight is given to cell-edge users for power allocation

b. POWER ALLOCATION FOR CELL-CENTER USERS

The objective is to conditionally maximize the performance of cell-edge users and there is no optimization for cell-center users, though protection of their performance is stated as an important constraint. Thus, we simply determine the power allocation to cell-center users by evenly distributing the total power for cell-center users among their used PRBs in each cell.

c. POWER ALLOCATION FOR CELL-EDGE USERS

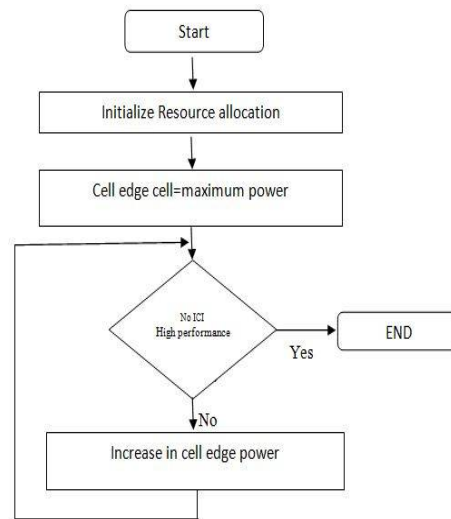
Given the fixed PRB allocation and power allocation of cell center users, the original optimization problem becomes a convex function of power of cell-edge users and can be decomposed into parallel sub-problems, where the optimal power allocation to cell-edge users is solved locally by each BS of the network. Where only mutual interference between cell-edge and cell-center users is taken into account.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

flow chart for Power Allocation



The Maximum power is allocated to cell edge user, constant power is allocated to cell center users.

V. PERFORMANCE ANALYSIS

TABLE I
MAIN SIMULATION PARAMETERS

Parameter	Value
Number of cells	7
Cell radius	500m
Bandwidth	5 MHz
Carrier frequency	2 GHz
Cell-edge area ratio	1/3of the total cell area
LOS path loss model	$103.4+24.2\log_{10}(d)\text{dB,din}$
NLOS path loss model	$131.1+42.8\log_{10}(d)\text{dB,din}$
Channel model	Rayleigh multipath model

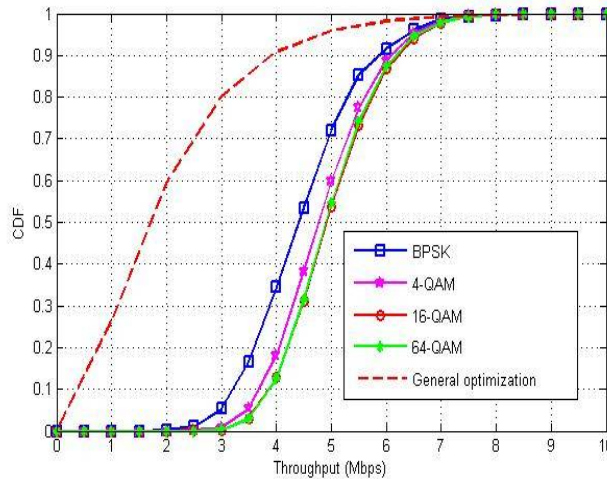
the average throughput achieved by the proposed scheme for both cell-edge and cell-center users in the reference cell. Here the values of modulator are chosen as [64-QAM]and the number of the users in each cell is 10.

The performance of the proposed scheme with different values of the modulator and various numbers of users per cell are evaluated. Therefore, we fix the SINR threshold value as 16 dB in the following proposed schemes, though it may not result in the exact performance balance when other modulators are used.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

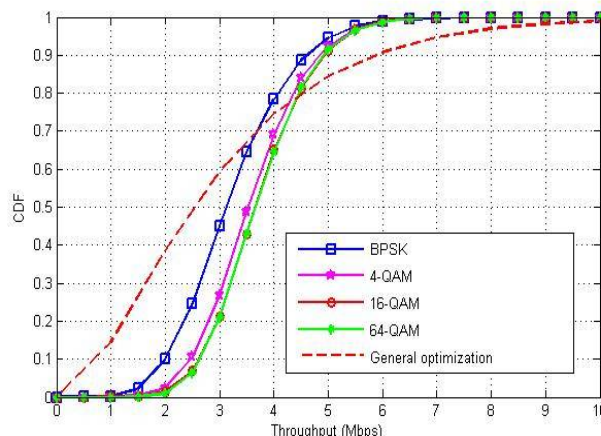


Performance in cell edge user

The cumulative distribution functions (CDF) of throughputs achieved by the different schemes for cell-edge and cell-center users of the reference cell in the network with 10 users per cell, respectively.

In addition to the aforementioned benchmark schemes for comparison, we investigate performance of the proposed scheme with various values of the modulator. proposed schemes can achieve significant improvement for cell-edge users over the reference schemes, where the general optimization scheme surprisingly performs worst. On the other hand, the general optimization scheme maximizes the performance of cell-center users and greatly outperforms other schemes.

It is because that the general optimization scheme targets overall performance maximization and thereby allocates resources (PRBs and power) dominantly to users with good channel conditions, e.g., cell-center users. Nevertheless, our schemes can successfully maintain high performance for cell-center users, i.e., 50% cell-center users can achieve throughput over 3 Mbps and nearly all of them can achieve throughput over 2 Mbps compared to 80% by the general optimization scheme and 60% by the dynamic SFR scheme reaching the target of 2 Mbps, respectively. Among the proposed schemes, in addition, [64-QAM] indicates high modulator given to cell-edge users for resource allocation and thereby yields the best performance to cell-edge users while lowest for cellcenter users. In contrast, [16-QAM] achieves the best performance for cell-center users and lowest for cell edge users.



Performance in cell center user

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

However, it is noticed that the performance achieved by all the schemes for the overall network surpasses that of the reference cell. This is because, with the exception of the reference cell, each cell of the considered 7-cell network is only partially surrounded by neighboring cells and thus suffers from less ICI than the reference cell does. Therefore, the performance improvement of our proposed schemes has been comprehensively evaluated by the single cell and 7-cell network scenarios, where full and partial ICI are experienced respectively.

VI. SUMMARY AND CONCLUSION

The optimal solution is obtained by the proposed scheme can achieve significant performance improvement for cell-edge users and desirable performance for cell-center users compared with the reference schemes. The spectrum usage also reduced. Also the consistent improvement is verified by performance evaluation on various user densities in the network. Therefore, the proposed resource allocation scheme can yield balanced performance between cell-edge and cell-center users, which allows for future wireless networks to deliver consistent high performance to any user from anywhere.

REFERENCES

- [1] Yawed Yu, Xiaojing Huang, Eryk Dutkiewicz, Markus Mueck, "Downlink resource allocation for next generation wireless networks with inter-cell interference," *IEEE Trans. Wireless Comm.*, vol. 12, no. 4, pp. 1783–1793, 2013
- [2] G. Li and H. Liu, "Downlink radio resource allocation for multi-cell OFDMA system," *IEEE Trans. Wireless Commun.*, vol. 5, no. 12, pp. 3451–3459, 2006.
- [3] J. Panicker, Y. G. Boudreau, N. Guo, R. Chang, and S. Vrzic, N. Wang, "Interference coordination and cancellation for 4G networks," *IEEE Comm. Mag.*, vol. 47, no. 4, pp. 74–81, 2009
- [4] M. Necker, "Interference coordination in cellular OFDMA networks," *IEEE Network*, vol. 22, no. 6, pp. 12–19, 2008.
- [5] M. Rahman, H.W. Wong, and Yanikomeroğlu, "Interference avoidance with dynamic inter-cell coordination for downlink LTE system," in *Proc. 2009 IEEE Wireless Comm and Networking Conference*, pp. 1–6.
- [6] N. Ksairi, P. Bianchi, P. Ciblat, and W. Hachem, "Resource allocation for downlink cellular OFDMA systems—part II: practical algorithms and optimal reuse factor," *IEEE Trans. Signal Process.*, vol. 58, no. 2, pp. 735–749, 2010.
- [7] N. Ksairi, W. Hachem, P. Bianchi, and P. Ciblat, "Resource allocation for downlink cellular OFDMA systems—part I: optimal allocation," *IEEE Trans. Signal Proc.*, vol. 58, no. 2, pp. 720–734, 2010.
- [8] T. D. Novlan, R. K. Ganti, A. Ghosh, and J. G. Andrews, "Analytical evaluation of fractional frequency reuse for OFDMA cellular networks," *IEEE Trans. Wireless Commun.*, vol. 10, no. 12, pp. 4294–4305, Dec. 2011.
- [9] X. Huang, Yu, E. Dutkiewicz, and M. Mueck, "Load distribution aware soft frequency reuse for inter-cell interference mitigation and throughput maximization in LTE networks," in *Proc. 2011 IEEE International Conference on Communications*, pp. 1–6.
- [10] X. Mao, A. Maaref, and K. Teo, "Adaptive soft frequency reuse for intercell interference coordination in SC-FDMA based 3GPP LTE uplinks," in *Proc. 2008 IEEE Global Telecommunications Conference*, pp. 1–6.
- [11] Y. Lin, T. Chiu, and Y. Su, "Optimal and near-optimal resource allocation algorithms for OFDMA networks," *IEEE Trans. Wireless Comm.*, vol. 8, no. 8, pp. 4066–4077, 2009.