Joint Optimization of The two Tier Femtocell and Macrocell Users OFDMA Network

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Abstract—We proposed a novel joint sub channel and resource allocation for the two-tier OFDMA network. The multi-cell OFDMA network not only has to control the interference to the users, but also has to coordinate the cross-tier interference. A resource allocation scheme for cross-channel Femto and Macro is proposed, aiming to maximize the capacity. We formulate this joint optimization for both uplink and downlink in OFDMA network will be considered. To efficiently solve this problem using dual decomposition and low complexity methods. The resulting schemes efficiently allocate the resource and data sharing in a distributed way. The simulation results show that the less interference and provide significant throughput.

Index Terms—Dual decomposition, Femtocell and Macrocell, Resource allocation, Sub channel, Interference management.

1 INTRODUCTION

Femtocells cover an even smaller space like a house or small business. They are sold by the operator, but self-installed by the customer. Some Femtocells may be autonomous implying that they have the ability to determine the best frequency and power levels to operate. The two arguments in favor of small cells are the reduced capital and operational expenditure (CAPEX and OPEX) as compared techniques like cell splitting and ability of small cells to provide adequate coverage in extremely densely populated areas. The idea of merging small cells with the Macro cell network has the advantage of offloading traffic from the bigger cell sites to the smallest cells. This permits the Macro cells to operate at their normal capacity. Such consolidation is transparent to the customer. It involves seamless handoff between the multiple sized cells and facilitates uninterrupted data services for the user. A key component of Het Net which will help in meeting the above requirements is network intelligence. Macro and Femtocells along with Wi-Fi have to be integrated into a single framework in a manner which avoids interference. As far as frequencies are concerned, all cells in heterogeneous network need not be using the same spectrum.

Macro cells can operate at a lower frequency to boost penetration. Higher bandwidth (bits/Hz) is desired for smaller cells, so it would be best to allocate higher frequencies to such cells. Since these works, joint sub channel and power allocation with QOS and cross-tier interference consideration has rarely been studied. In a non-cooperative power and sub channel allocation for co-channel deployed Femtocells is proposed, together with Macrocell user transmission protection. Femtocell networks should support heterogeneous QOS for delay-sensitive services such as online gaming and video phone calls, while maximizing the throughput of delay-tolerant services. In resource allocation for mixed services under a total power constraint in OFDMA systems is investigated.

In a dual decomposition method based sub channel selection and power allocation, subject to interference temperature limit, is studied in CR networks. In sub channel and power allocation based on discrete stochastic optimization is proposed for CR networks considering heterogeneous QOS users. In this paper, we focus on the sub channel and power allocation problem in OFDMA based the two-tier Femtocell networks, in which a central Macrocell is overlaid with spectrum-sharing Femto cells. Moreover, the types of interference in the two-tier networks are classified as follows:
• **Co-tier interference:** This type of interference occurs between network elements that belong to the same tier in the network. In case of a Femtocell network, Co-tier interference occurs between neighboring Femtocells.

• **Cross-tier interference:** This type of interference occurs between network elements that belong to the different tiers of the network, i.e., interference between Femtocells and Macrocells.

• Femtocells interfering with Macrocell on the same spectrum.

• Macrocell interfering with Femtocell on the same spectrum.

• Neighboring Femtocells that are close, interfering with each other on the same spectrum.

• User hand-equipment transmitting with high power may reach the Macrocell that influences the level of noises received by the Macrocell.

The designers claim that Femtocell can provide the best coverage within a range of 40m and can support connection to users who are travelling at speed up to 120 Km/h. So the optimum distance between the two Femtocells should be around 80m. Though based on the Femto cell class (1–3), the coverage range varies from 10–40 m.

The classes of the Femtocell variation among these three based on its operation in residential and enterprise application. In an ideal heterogeneous network, there is very little chance of co-tier interference if Femtocells are deployed with proper planning. However, the “plug and play” feature that Femtocell offers cannot be included in any network planning. So mitigating interference in heterogeneous network is a big problem for network planners. In the heterogeneous network, the target is to use minimum frequency reuse factor.

## 2 System Model

### 2.1 Interference Mitigation Techniques

Many techniques have been tested and deployed to mitigate the interferences in Femtocell network. They can be classified based on different criteria and according to their ability to improve the link reliability as well as the capacity. The user centric approach imitates the satisfaction of the users on the service of the network. The users get the main focus and the resources are allocated to guarantee user satisfaction. As a result, it maximizes the available resources of the system that can before matted as:

\[
\max_p \sum_{n=1}^{N} p^n \sum_{k=1}^{K} \frac{1}{KU} R_k^n q_k^n
\]

\[
\sum_{n=1}^{N} p^n \leq P_{\text{max}}, \sum_{k=1}^{K} q_k^n \leq 1
\]

Where, \( q(n) \) and \( U(r(n), k) \) are the variable sub-carrier assignment variable and the unity function, respectively.

When sub-carrier is assigned to users, the value of is 1 otherwise its 0. On the other hand, system centric approach concentrates on the QOS of the system. Instead of monitoring individual’s satisfaction, it studies the overall performance of the network. System centric arrangement can be classified into the two sub-systems: Radio, adaptive system and The margin adaptive system. In radio, adaptive system, the QOS of the users are maximized which can be formatters

\[
\sum_{n=1}^{N} p^n \leq P_{\text{max}}, p^n > 1
\]

Where, \( p(n), G(n) \) and \( N \) are the total bandwidth, transmitting power, channel gain and the number of subscribers, respectively. Conversely, The margin adaptive system emphasizes on minimizing the transmission power of FBS that can be expressed as where \( R \) is the required data rate of the user.

### 2.2 Resources Allocation

A core building block enables Femtocells to find the available resources in a completely distributed resource management framework that effectively manages the interference. A frequency splitting techniques to solve the interference problem in Femtocells network where multiple access interference (MAI) and Inter-Carrier Interference (ICI) influence the system’s performance. Clustering Algorithms are proposed in where the whole bandwidth is allotted into the two bands. One is dedicatedly assigned to Femto-users and another is for Macro-users. The ratio of the bands is fixed by the given “Clustering” technique.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Quantity</th>
<th>Conversion from Gaussian and CGS EMU to SI³</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Phi )</td>
<td>magnetic flux</td>
<td>1 Mx = 10⁻⁸ Wb = 10⁻¹² V·s</td>
</tr>
<tr>
<td>( B )</td>
<td>magnetic flux density, magnetic induction</td>
<td>1 G = 10⁻⁴ T = 10⁻⁷ Wb/m²</td>
</tr>
<tr>
<td>( H )</td>
<td>magnetic field strength</td>
<td>1 Oe = 10³(4π) A/m</td>
</tr>
<tr>
<td>( m )</td>
<td>magnetic moment</td>
<td>1 erg/G = 1 emu</td>
</tr>
<tr>
<td>( M )</td>
<td>magnetization</td>
<td>1 erg/(G·cm³) = 1 emu/cm³</td>
</tr>
<tr>
<td>( 4\pi M )</td>
<td>magnetization</td>
<td>1 G = 10⁻⁷(4π) A/m</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>specific magnetization</td>
<td>1 erg/(G·cm) = 1 emu/g → 1 A m²/kg</td>
</tr>
<tr>
<td>( j )</td>
<td>magnetic dipole moment</td>
<td>1 erg/G·cm³ = 1 emu/cm³</td>
</tr>
<tr>
<td>( J )</td>
<td>magnetic polarization</td>
<td>1 erg/G·cm³ = 1 emu/cm³</td>
</tr>
<tr>
<td>( \chi, \kappa )</td>
<td>susceptibility</td>
<td>1 → 4π</td>
</tr>
<tr>
<td>( \chi_0 )</td>
<td>mass susceptibility</td>
<td>1 cm³/g → 4π × 10⁻³ m³/kg</td>
</tr>
<tr>
<td>( \mu )</td>
<td>permeability</td>
<td>1 → 4π × 10⁻³ H/m</td>
</tr>
<tr>
<td>( \mu_0 )</td>
<td>relative permeability</td>
<td>1 → 4π × 10⁻³ Wb/(A·m)</td>
</tr>
<tr>
<td>( w, W )</td>
<td>energy density</td>
<td>1 erg/cm³ → 10⁻³ J/m³</td>
</tr>
<tr>
<td>( N, D )</td>
<td>demagnetizing factor</td>
<td>1 → 1/(4π)</td>
</tr>
</tbody>
</table>

**Statements that serve as captions for the entire table do not need footnote letters.**

**Gaussian units are the same as cgs emu for magnetostatics:**

\( M = \) Maxwell, \( G = \) Gauss, \( OE = \) Oersted, \( Wb = \) Weber, \( V = \) volt, \( s = \) second, \( T = \) tesla, \( m = \) meter, \( A = \) ampere, \( J = \) joule, kg = kilogram, H = Henry.

Increasing BTS capacity and tuning parameters of the resources are also included in the hardware approach in terms of dealing interferences. Based on resource partitioning and power management, self-organized approaches can be categorized as centralized method and distributed method. Below some of the algorithms which based on interference mitigation are discussed.
3 SIMULATION RESULTS

Simulation results are given in this section to evaluate the performance of the proposed resource allocation algorithms.

In the simulations, spectrum-sharing Femtocells are uniformly distributed in the Macrocell coverage area and, Femto users are distributed in the coverage area of their serving Femtocell. The coverage radius of the Macrocell is 500 m, and that of a Femtocell is 10 m. A round-robin scheme is adopted for Macro user scheduling in the simulation. The MBS-Macro user’s lognormal shadowing is 8 dB.

4 CONCLUSIONS

In this paper, interference is limiting both outdoor and indoor throughputs (e.g. for edge SNR of 30 dB), it is shown that indoor throughputs can even exceed outdoor throughputs due to the asymmetric shielding effects of the walls for different base stations, which can result increased indoor SINR. Since increase the data sharing capacity using OFDMA network.

ACKNOWLEDGMENTS

A large number of people generously contributed to this special issue, including the authors, reviewers, parents, friends and IJTET staffs.

REFERENCES


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