Maximizing Dual Cell Connectivity Opportunities in LTE Small Cells Deployment

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Introduction

- In an attempt to meet the data rates for indoor users, 4G LTE network operators are deploying more small cells like Femtos and picos.
- Small cells help to improve indoor users high data rates and reduce CAPEX and OPEX to operators.
- Frequent handovers, load imbalance and high interference are major issues in unplanned dense deployment of small cells.
- Cell edge users are major victims, who experience low throughput because of weak signal strength and high interference.
- The overlapping regions dense small cell deployment can be exploited by the network operators by allowing more dual cell connectivity (DCC) for cell edge users in the overlapping region.
- In our work, we maximize the DCC opportunities to indoor users by deploying small cells using optimal placement with full power (OPT-FP) or opportunistic placement with power control (OPPR-PC) models.
- To ensure fair allocation of resources to all the users in the network, proportional fair (PF) scheduling algorithm is incorporated.

DCC Placement Models

\[
\text{OPT-FP Model} \\
\max_{\{i, j\}} \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} \quad (1) \\
\text{SNR}_{ij} = \frac{P_{ij}}{\sigma_{i}^{2}} \quad (2) \\
1 \leq x_{ij} \leq |SR| \quad \forall j \in F \quad (3) \\
\sum_{i=1}^{m} \sum_{j=1}^{n} \text{SNR}_{ij} \geq \gamma \quad (4) \\
\text{OPPR-PC Model} \\
\max_{\{i, j\}} \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} \quad (5) \\
\text{SNR}_{ij} = \frac{P_{ij}}{\sigma_{i}^{2}} \quad (6) \\
\text{Finally the OPPR-PC model is formulated as follows,} \\
\max_{\{i, j\}} \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} \quad (7)
\]

Simulation Setup & Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Dimensions</td>
<td>48 m x 48 m x 4 m</td>
</tr>
<tr>
<td>Macro BS Height</td>
<td>30 m</td>
</tr>
<tr>
<td>Number of floors</td>
<td>One</td>
</tr>
<tr>
<td>Femto Placement</td>
<td>Ceiling [center of sub-region]</td>
</tr>
<tr>
<td>Buffer Status</td>
<td>First Buffer</td>
</tr>
<tr>
<td>Femto Bandwidth</td>
<td>5 MHz [25 MHz]</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>100 s</td>
</tr>
<tr>
<td>Power margin against JE</td>
<td>20 dBm, 46 dBm, and 4 dB</td>
</tr>
</tbody>
</table>

Results & Analysis

- Due to the smaller coverage region of small cells, load balancing and user-level fairness across small cells is a serious problem.
- Existing works explored sub-optimal ways of load balancing by tuning the hysteresis threshold margins and by varying the transmit power of cells.
- Optimal placement of Femtos ensure no coverage hole with minimum number of Femtos but a chance of imbalance in traffic load in these small cells owing to mobility of the users.
- One solution can be while deploying small cells, operators can maximize the coverage area of all small cells and there by increase the possibility of joint scheduling for the cell edge users.
- Existing work on joint scheduling talks about uncoordinated power control in uplink between Macro and small cells, but this increase the burden on backhaul and reduce the battery life of UE. Another work talks about forced cooperative downlink packet scheduling with the same radio resource.

Proposed work

- In this work, we provide two placement model to improve the indoor data rate.
  - Optimal Full power (OPT-FP) Model
  - Opportunistic Power Control (OPPR-PC) Model

References


Conclusion

- In this work, we proposed an optimal Femto placement model OPT-FP and OPPR-PC for a fixed user occupancy pattern to maximize DCC opportunities in indoor environments.

Acknowledgement

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