Inter-Cell Interference Impact on LTE Performance in Urban Scenarios

Diogo X. Almeida, Luís M. Correia, Marco Serrazina

Instituto Superior Técnico / INOV-INESC
University of Lisbon, Portugal

(22/11/2013)
Outline

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Motivation

• Data traffic is growing exponentially, which forces mobile operators to increase capacity.

• Operators may adopt a universal frequency reuse and deploy increasingly smaller cell sizes, but inter-cell interference becomes higher.

• Hence, a capacity increase should take into account an inter-cell interference reduction, in order to serve a considerable number of users with a relatively high throughput.
Models

• For the inter-cell interference analysis, several models are considered:
  • The allocation of users to sectors is based on the received power (given by the COST-231 Walfisch-Ikegami propagation model).
  • The interfering power takes into account sub-carriers placed in the same frequency as the desired signal.
  • Throughput is considered as a function of SINR and is based on expressions derived in this work.
  • The Resource Blocks (RBs) distribution along the spectrum is contiguous.
LoS Occurrence

- A stochastic assignment of LoS conditions is considered (saturation to 1 is assumed):

\[
P_{\text{LoS}} = \begin{cases} 
  k \frac{h_b[m] - H_B[m]}{h_b[m]} \frac{d_{co}[m] - d[m]}{d_{co}[m]}, & d < d_{co} \land h_b \geq H_B \\
  0, & d \geq d_{co} \land h_b < H_B
\end{cases}
\]

where:
- \( k \): scaling factor (3);
- \( h_b \): height of the antenna;
- \( H_B \): height of the buildings;
- \( d_{co} \): cut-off distance;
- \( d \): distance between the antenna and the user.
Radiation Pattern

- Both horizontal and vertical radiation patterns are considered. In the latter, the vertical angle depends on whether the user is under LoS conditions or not.
- Electrical and mechanical downtilts are analysed.
Scenarios (1)

- An analysis of the effect of the antenna’s electrical and mechanical downtilts, height, and output power on interference minimisation is performed.
- The following scenarios are analysed in dense urban (centre of Lisbon) and urban (off-centre of Lisbon) environments:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>800 MHz band</th>
<th>1 800 MHz band</th>
<th>2 600 MHz band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth [MHz]</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Output power [dBm]</td>
<td>44.8</td>
<td>46.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Half-power beamwidth (vertical) [°]</td>
<td>10.3</td>
<td>4.8</td>
<td>3.5</td>
</tr>
</tbody>
</table>

- Category 3 User Equipments with 2×2 MIMO are used.
Scenarios (2)

- FTP is the only service considered in the low load scenarios.
- In the high load scenarios analysis, the following traffic mix is considered:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Video streaming</td>
<td>1</td>
<td>1.024</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Chat</td>
<td>2</td>
<td>0.064</td>
<td>0.384</td>
<td>5</td>
</tr>
<tr>
<td>Web browsing</td>
<td>3</td>
<td>1.024</td>
<td>100</td>
<td>24</td>
</tr>
<tr>
<td>FTP</td>
<td>4</td>
<td>1.024</td>
<td>100</td>
<td>9</td>
</tr>
<tr>
<td>E-mail</td>
<td>5</td>
<td>1.024</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>P2P</td>
<td>6</td>
<td>1.024</td>
<td>100</td>
<td>17</td>
</tr>
</tbody>
</table>
Low Load Scenarios (1)

- Simulations show that interference is not negligible in the 800 MHz band.
Low Load Scenarios (2)

- In the simulations, sharing of RBs among users was more frequent than in measurements.
High Load Scenarios (1)

- When interference is neglected, the lower the frequency band the higher the number of users served, because of a higher sector antenna’s range.
High Load Scenarios (2)

- Relatively high standard deviations are due to users in either LoS or NLoS conditions at different distances from the antennas and requesting different services.
Electrical Downtilt (1)

- The higher the frequency band the lower is the optimal downtilt, which can be explained by a decreasing vertical half-power beamwidth.
• For the off-centre, 11°, 9° and 9° of electrical downtilt enhance throughput for the 800, 1800 and 2600 MHz bands, respectively, by 4.3%, 17.2% and 20.4%.
Results

• The highest improvements on the number of served users happen for a transmitter output power of 10 W for the 1 800 MHz band on both the centre (11.6% improvement) and off-centre (6.9% improvement).

• The maximum throughput enhancements occur for an electrical downtilt of 11° for the 1 800 (27.3% improvement) and 2 600 MHz (18.9% improvement) in the centre, and 9° for the 1 800 (17.2% improvement) and 2 600 MHz (20.4% improvement) in the off-centre.
Conclusions

• In this work, an evaluation of LTE performance in urban scenarios concerning inter-cell interference via antenna aspects was performed.

• A stochastic generation of LoS occurrences, a contiguous spectrum allocation, the radiation pattern of the antennas and a received power based association of users to sectors was considered in a program intended to simulate a real network as close as possible.

• It was found that output power and electrical downtilt provide the best improvements on the number of users served per sector and user’s throughput, respectively.
Questions