Impact of femtocell positions on traffic sharing in LTE enterprise scenarios

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Introduction

- Previous work (COST meetings): Traffic Sharing Techniques in Enterprise LTE Femtocells

- Previous contribution
  a. Enterprise (opened) femtocell scenario (regular layout).
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  b. LTE dynamic system-level simulator
     - Propagation models (WINNER II)
     - Mobility model (traces)
Introduction

- Previous work (COST meetings): Traffic Sharing Techniques in Enterprise LTE Femtocells

- Previous contribution
  a. Enterprise (opened) femtocell scenario (regular layout).
  b. LTE dynamic system-level simulator
     - Propagation models (WINNER II)
     - Mobility model (traces)
  c. Several traffic sharing techniques are tested with service area changes (HO margins and power transmission)

\[
\text{HO margin changes: } (i,j) \\
\text{Transmission power changes: } (i)
\]
Introduction

- Additional performance assessment

The impact of femtocell positions (irregular layout) on traffic sharing techniques capability is evaluated.
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Basic algorithms (Individual approaches)

1) **MTS**: HO margin modifications depending on Blocking ratio differences (adjacent basis)
Basic algorithms (Individual approaches)

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2) **MTSC**: Similar to MTS, but margin changes are restricted to a limited interval so as to avoid connection quality problems.
Algorithm outline

**Basic algorithms** (Individual approaches)

1) **MTS**: HO margin modifications depending on Blocking differences (adjacent basis)
2) **MTSC**: Similar to MTS, but margin changes are restricted to a limited interval so as to avoid connection quality problems.
3) **PTS**: Tx power modifications depending on blocking differences (cell basis)

\[ BR_{diff}(i) = BR(i) - \frac{\sum_{j \in N(i)} BR(j)}{|N(i)|} \]
Strategies (Combining individual approaches. 50 optimization loops)

1) MTSC-PTS: MTSC is enabled only for the first 25 loops and PTS is then activated for the rest of the simulation.
Algorithm outline

**Strategies** (Combining individual approaches. 50 optimization loops)

1) **MTSC-PTS**: MTSC is enabled only for the first 25 loops and PTS is then activated for the rest of the simulation.

2) **MTSC-PTS**: PTS is enabled only for the first 25 loops and MTSC is then activated for the rest of the simulation.

[Diagram showing the sequence of loops with MTSC and PTS enabled at different points]
**Algorithm outline**

**Strategies** (Combining individual approaches. 50 optimization loops)

1) **MTSC-PTS**: MTSC is enabled only for the first 25 loops and PTS is then activated for the rest of the simulation.

2) **MTSC-PTS**: PTS is enabled only for the first 25 loops and MTSC is then activated for the rest of the simulation.

3) **MTSC&PTS**: Both MTSC and PTS are executed simultaneously in all the 50 loops.
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2) **MTSC-PTS**: PTS is enabled only for the first 25 loops and MTSC is then activated for the rest of the simulation.

3) **MTSC&PTS**: Both MTSC and PTS are executed simultaneously in all the 50 loops.

4) **CTS**: MTSC is activated first. Then, switching to PTS occurs when MTSC cannot improve network performance (MTSC reaches its limits or traffic balance is reached).
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**Analysis set-up**

### Scenarios

**Scenario 1**
Traffic sharing in the same floor

**Scenario 2**
Traffic sharing between different floors

**Scenario 3**
Complex scenario
Analysis set-up

Simulations

10 simulations with different femtocell positions (irregular layout) per each of the following cases have been carried out:

1) **S1 MTS.** Algorithm MTS in scenario 1.
2) **S1 MTSC.** Algorithm MTSC in scenario 1.
3) **S1 PTS.** Algorithm PTS in scenario 1.
4) **S2 PTS.** Algorithm PTS in scenario 2.
5) **S3 MTSC-PTS.** Strategy MTSC-PTS in scenario 3.
6) **S3 PTS-MTSC.** Strategy PTS-MTSC in scenario 3.
7) **S3 MTSC&PTS.** Strategy MTSC&PTS in scenario 3.
8) **S3 CTS.** Strategy CTS in scenario 3.

Results are compared with regular layout simulated in previous work (benchmark).

Performance indicators

\[
\text{CBR} = \text{Blocked calls / total calls} \\
\text{OR} = \text{Unserved time / (served time + unserved time)}
\]

\[
\Rightarrow \quad UUR^{(0)} = BR + OR(1 - BR)
\]

\[
UUR_{imp}^{(n)} = \frac{(UUR^{(0)} - UUR^{(n)})}{UUR^{(0)}}
\]
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Results

Benchmark results (Regular layout in Scenario 3)

\[ UUR_{imp}^{(50)} = \left( \frac{\sim 0.17 - \sim 0.08}{0.17} \right) \approx 0.52 \]

\( \Rightarrow \) Any of the strategies reach a \( UUR_{imp}^{(50)} \) higher than 40%. 

\[ UUR_{imp}^{(50)} = \left( \frac{\sim 0.17 - \sim 0.08}{0.17} \right) \approx 0.52 \]
⇒ Regular layout can be considered as a worst case for S1 MTS, S1 PTS and S2 PTS, and a representative case for S1 MTSC, S3 CTS, S3 MTSC&PTS, S3 MTSC-PTS and S3 PTS-MTSC.
## Results

### S3 CTS

<table>
<thead>
<tr>
<th>Positions</th>
<th>$UUR^{(0)}$</th>
<th>$min(UUR)$</th>
<th>$UUR^{(50)}$</th>
<th>$max(UUR_{imp})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>17.2%</td>
<td>7.44%</td>
<td>7.87%</td>
<td>56.74%</td>
</tr>
<tr>
<td>Irr. 1</td>
<td>20.9%</td>
<td>4.36%</td>
<td>5.24%</td>
<td>79.14%</td>
</tr>
<tr>
<td>Irr. 2</td>
<td>11.2%</td>
<td>3.55%</td>
<td>4.15%</td>
<td>68.30%</td>
</tr>
<tr>
<td>Irr. 3</td>
<td>4.57%</td>
<td>2.15%</td>
<td>2.52%</td>
<td>52.95%</td>
</tr>
<tr>
<td>Irr. 4</td>
<td>10.4%</td>
<td>3.66%</td>
<td>4.33%</td>
<td>64.81%</td>
</tr>
<tr>
<td>Irr. 5</td>
<td>18.3%</td>
<td>6.64%</td>
<td>7.57%</td>
<td>63.72%</td>
</tr>
<tr>
<td>Irr. 6</td>
<td>16.5%</td>
<td>6.1%</td>
<td>7.11%</td>
<td>63.03%</td>
</tr>
<tr>
<td>Irr. 7</td>
<td>10.4%</td>
<td>2.93%</td>
<td>3.59%</td>
<td>71.83%</td>
</tr>
<tr>
<td>Irr. 8</td>
<td>20%</td>
<td>5.14%</td>
<td>5.93%</td>
<td>74.30%</td>
</tr>
<tr>
<td>Irr. 9</td>
<td>16.1%</td>
<td>4.38%</td>
<td>5.18%</td>
<td>72.80%</td>
</tr>
<tr>
<td>Irr. 10</td>
<td>8.16%</td>
<td>2.69%</td>
<td>3.94%</td>
<td>67.03%</td>
</tr>
</tbody>
</table>

⇒ Maximum $UUR_{imp}$ is between **79.14%** (best) and **52.95%** (worst).

⇒ This is a clear evidence of the robustness of CTS strategy, wherever femtocells are located.
Results

<table>
<thead>
<tr>
<th>Positions</th>
<th>$UUR^{(0)}$</th>
<th>$min(UUR)$</th>
<th>$UUR^{(50)}$</th>
<th>$max(UUR_{imp})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>17,2%</td>
<td>7,52%</td>
<td>8,86%</td>
<td>56,28%</td>
</tr>
<tr>
<td>Irr. 1</td>
<td>20,9%</td>
<td>4,41%</td>
<td>5,2%</td>
<td>78,90%</td>
</tr>
<tr>
<td>Irr. 2</td>
<td>11,2%</td>
<td>3,54%</td>
<td>4,25%</td>
<td>68,39%</td>
</tr>
<tr>
<td>Irr. 3</td>
<td>4,57%</td>
<td>2,21%</td>
<td>2,56%</td>
<td><strong>51,64%</strong></td>
</tr>
<tr>
<td>Irr. 4</td>
<td>10,4%</td>
<td>3,26%</td>
<td>3,67%</td>
<td>68,65%</td>
</tr>
<tr>
<td>Irr. 5</td>
<td>18,3%</td>
<td>6,06%</td>
<td>7,01%</td>
<td>66,89%</td>
</tr>
<tr>
<td>Irr. 6</td>
<td>16,5%</td>
<td>5,99%</td>
<td>6,65%</td>
<td>63,70%</td>
</tr>
<tr>
<td>Irr. 7</td>
<td>10,4%</td>
<td>1,43%</td>
<td>2,32%</td>
<td><strong>86,25%</strong></td>
</tr>
<tr>
<td>Irr. 8</td>
<td>20%</td>
<td>7,25%</td>
<td>10,3%</td>
<td>63,75%</td>
</tr>
<tr>
<td>Irr. 9</td>
<td>16,1%</td>
<td>7,43%</td>
<td>11,2%</td>
<td>53,85%</td>
</tr>
<tr>
<td>Irr. 10</td>
<td>8,16%</td>
<td>2,75%</td>
<td>3,74%</td>
<td>66,30%</td>
</tr>
</tbody>
</table>

⇒ Maximum $UUR_{imp}$ is between **86.25%** (worst) and **51.64%** (best).

⇒ This is a clear evidence of the robustness of MTSC&PTS strategy, wherever femtocells are located.
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Conclusions

- The impact of femtocell access point positions when redistributing traffic demand between LTE femtocells in an enterprise scenario have been analyzed.

- Several traffic sharing techniques have been tested with different positions of femtocells access points. Regular layout (previously simulated) and irregular layout have been compared.

- Results show that regular layout can be considered as a worst case in terms of traffic sharing capability (representative case in some scenarios).

- In the worst case, the $\text{UUR}_{\text{imp}}$ for combined strategies in irregular scenarios is higher than 50%. A clear evidence of the traffic sharing techniques robustness.