Effectiveness of Cell Outage Compensation in LTE Networks

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OUTLINE

- INTRODUCTION
- ASSESSMENT APPROACH
- NUMERICAL RESULTS
- CONCLUDING REMARKS
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INTRODUCTION

• LTE
  • Mobile cellular network technology
  • E-UTRAN, a.k.a. ‘Long Term Evolution’
  • Standardised by 3GPP R8-…
  • 3.9G successor to UMTS
  • Key features
    • OFDM
    • MIMO
    • SON
    • …
INTRODUCTION

• Cell outage management / self-healing
  • Automatic detection and compensation of ‘outages’
    • eNodeB failure, cell failure, physical signal/channel failure
    • Enhances robustness/resilience

Operator policy: Coverage, QoS

Coverage/QoS map estimation

Control parameters

Detection

Compensation

Measurements
INTRODUCTION

- Cell outage management / self-healing
  - Control parameters
    - Transmit power settings
    - Antenna downtilt
      - Azimuth/beamforming
      - Scheduler’s fairness parameter
      - Intra/inter-RAT handover parameters, load balancing
      - Neighbour cell lists
      - …
INTRODUCTION

• Cell outage management / self-healing
  • Control parameters
    • Transmit power settings

DOWNLINK

• $P_{\text{MAX}} = P_{\text{PILOT}} + P_{\text{DATA}} = \text{fixed}$
• Raising $P_{\text{PILOT}}$ increases coverage, but decreases $P_{\text{DATA}}$ and hence the traffic handling capacity/quality
• An increased coverage also implies more absorbed traffic, hence more resource sharing and less per-user QoS

UPLINK

• $P_0 \equiv \text{target received power density (per RB)}$
• Reducing $P_0$ lowers inter-cell interference levels and hence increases coverage
• Reducing $P_0$ lowers the achievable MCS and hence throughput/QoS per RB
• An increased coverage also implies more absorbed traffic, hence more resource sharing and less per-user QoS
INTRODUCTION

• Cell outage management / self-healing
  • Control parameters
    • Antenna downtilt

• Raising TILT increases coverage, but also increases inter-cell interference
• An increased coverage also implies more absorbed traffic, hence more resource sharing and less per-user QoS
INTRODUCTION

• Objective

TO ASSESS THE EFFECTIVENESS OF $P_{\text{PILOT}}$, $P_0$ AND TILT IN MITIGATING THE EFFECTS OF CELL OUTAGES IN DIFFERENT SCENARIOS
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ASSESSMENT APPROACH

- **Scenarios**
  - Diverse aspects are of potential interest …
    - Site density
    - Traffic load
      - Service mix
      - Spatial traffic distribution
      - User mobility
      - Propagation environment
      - …
ASSESSMENT APPROACH

- **Scenarios**
  - $\text{COV}_L$: Coverage-oriented network layout with low traffic load
  - $\text{CAP}_L$: Capacity-oriented network layout with low traffic load
  - $\text{CAP}_M$: Capacity-oriented network layout with medium traffic load
  - $\text{CAP}_H$: Capacity-oriented network layout with high traffic load

<table>
<thead>
<tr>
<th></th>
<th>Capacity-driven layout</th>
<th>Coverage-driven layout</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-site distance</td>
<td>500 m</td>
<td>2200 m</td>
</tr>
<tr>
<td>Antenna downtilt</td>
<td>15°</td>
<td>5°</td>
</tr>
<tr>
<td>System bandwidth</td>
<td>10 MHz</td>
<td></td>
</tr>
<tr>
<td>$P_{\text{MAX,BS}} - P_{\text{BS}} - P_{\text{MAX,UE}}$</td>
<td>46 dBm, 33 dBm, 25 dBm</td>
<td></td>
</tr>
<tr>
<td>Path loss</td>
<td>$128.1 + 37.6 \log_{10} r$, with $r$ in km</td>
<td></td>
</tr>
<tr>
<td>Shadowing</td>
<td>$\sigma = 8$ dB, inter-site correlation of $\frac{1}{2}$, decorrel. distance = inter-site distance / 15</td>
<td></td>
</tr>
<tr>
<td>Antenna model</td>
<td>3GPP 3D model</td>
<td></td>
</tr>
<tr>
<td>Noise level</td>
<td>-199 dBW/Hz in DL, -195 dBW/Hz in UL</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td>Generic elastic data service with a requested throughput of 1 Mb/s (DL) &amp; 250 kb/s (UL)</td>
<td></td>
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</tbody>
</table>
ASSESSMENT APPROACH

• Performance metrics
  • Coverage probability
  • Uplink/downlink user throughput
  • Fraction of satisfied users, where ‘satisfied’ is …
    • Covered
    • Uplink throughput ≥ $\alpha \times 250$ kb/s
    • Downlink throughput ≥ $\alpha \times 1$ Mb/s
  ... and $\alpha$ reflects the operator policy in that it expresses the relative importance of coverage and quality

• When applicable, metrics are assessed over first tier of tells surrounding the outage area
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NUMERICAL RESULTS
NUMERICAL RESULTS

PRE-OUTAGE SITUATION
POST-OUTAGE SITUATION WITHOUT COMPENSATION
POST-OUTAGE SITUATION WITH OPTIMISED $P_0$

COVERAGE PROBABILITY

UPLINK USER THROUGHPUT

DOWNLINK USER THROUGHPUT
NUMERICAL RESULTS

COVERAGE-DRIVEN LAYOUT (LOW LOAD)

CAPACITY-DRIVEN LAYOUT (LOW LOAD)

CAPACITY-DRIVEN LAYOUT (MEDIUM LOAD)

CAPACITY-DRIVEN LAYOUT (HIGH LOAD)
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CONCLUDING REMARKS

- Cell outage management in LTE networks
- Assessment of compensation potential of adapting …
  - ... $P_{\text{PILOT}}$, $P_0$ and the antenna downtilt
- Key insights
  - Both the compensation potential and the most effective control parameter depend on the traffic load and the operator policy
    - $P_0$ and the antenna downtilt are most effective in improving coverage
    - $P_0$ and the antenna downtilt is most effective in improving user throughput
- Further research
  - Development of on-line algorithms for cell outage compensation
ACKNOWLEDGMENT
ANNOUNCEMENT

FP7 SOCRATES

Announcement

FP7 SOCRATES Final Workshop on

Self-Organisation in Mobile Networks

22 February 2011 - Karlsruhe, Germany

(Co-located with IWSOS 2011)

The goal of this open workshop is to disseminate the results achieved by the FP7 project SOCRATES (www.fp7-socrates.eu) and to stimulate discussions on the topic of self-organisation in future mobile networks. The program comprises presentations from SOCRATES and invited talks by renowned experts in the field. The SOCRATES project will also provide demonstrations of its results on self-optimisation, self-healing and self-configuration in LTE networks. Through interactions with the participants and the invited speakers, the consortium wants to promote and discuss its views and approaches on self-organising methods for beyond 3G mobile networks.

The workshop addresses both academic researchers and engineers. It mainly aims at research responsible, R&D engineers and technical developers involved in planning, deployment or operations & maintenance of beyond 3G networks, within telecom operators, telecom vendors and SMEs and large companies active in the telecom sector.

The workshop will take place the day before the 5th International Workshop on Self-Organizing Systems (IWSOS 2011), at the same location, Karlsruhe Palace in Karlsruhe, Germany. For more information on this location, travelling, etc., please check the IWSOS 2011 website (http://iwsos2011.in.kit.edu).