Analytical Validation of the IMT-Advanced Compliant openWNS LTE Simulator

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Outline

- Motivation
- IMT-A Channel Model & Scenario
- CIR Calculation for Indoor Hotspot Scenario
- LTE Layer 2 Calibration Assumptions
- Results
- Summary, Conclusion & Outlook
Motivation

- World Radio Conference 2007 (WRC-07) has identified new spectrum for mobile radio communication
- ITU-R controls the allocation of this spectrum
- Issued the IMT-Advanced process to evaluate candidate systems
Motivation

- Self evaluation: Done by bodies behind candidate Radio Access Technologies (RATs) (3GPP for LTE-A, IEEE for WiMAX-A)
- External evaluation: Done by others ex. WINNER+
  - Problem: How to verify used simulators => calibration

Calibration results for the Indoor Hotspot scenario

From: FINAL EVALUATION REPORT FROM WINNER+ ON THE IMT-ADVANCED PROPOSAL IN DOCUMENTS IMT-ADV/6, IMT-ADV/8 AND IMT-ADV/9
IMT-A Channel Model & Scenario

Done once per simulation run:

- **20 user terminals; uniformly random placed**
- Each terminal chooses channel condition on both BS links
  - Random, distance dependent
  - Line of sight (LoS) or non line of sight (NLoS)
  - Calculate pathloss $PL$
- Draw log-normal shadowing value $X$
- Associate to BS with lowest attenuation ($X + PL$) on link

Base Station (BS)
User Terminal (UT)
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![Diagram showing base stations and user terminals with distances and probability of LoS.](image)
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CIR Calculation for Indoor Hotspot Scenario

\[ p(CIR | s=1, c_1, c_2) \sim N(\mu_{2,c_2} - \mu_{1,c_1}, \sqrt{\delta_{1,c_1}^2 + \delta_{2,c_2}^2}) \mathbb{1}_{\{x>0\}} / P(s=1) \]
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CIR Calculation for Indoor Hotspot Scenario

\[ p(CIR|s=2, c_1, c_2) \sim N(\mu_1, c_1, \mu_2, c_2, \sqrt{\delta_1, c_1^2 + \delta_2, c_2^2}, 1_{\{x>0\}} / P(s=2) \]

[Diagram showing different path loss scenarios and CIR distributions]

- Path loss PL [dB]
- CIR [dB]
- s=1, LoS, LoS
- s=1, NLoS, LoS
- s=1, LoS, NLoS
- s=1, NLoS, NLoS
- s=2, LoS, LoS

[Graph showing probability distributions for different scenarios]
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CIR Calculation for Indoor Hotspot Scenario

\[ p(CIR|x,y) = \sum_{s,c_1,c_2} P(s)P(c_1)P(c_2)p(CIR|s,c_1,c_2) \]
CIR Calculation for Indoor Hotspot Scenario

Rate probability $P(r)$: Probability for each MCS

$$P(r|x,y) = \sum_{s,c_1,c_2} P(s)P(c_1)P(c_2)P(r|s,c_1,c_2)$$

CIR Calculation for Indoor Hotspot Scenario

- Integrate over the area and normalize to obtain scenario CIR & rate distribution

- No solution for integral is known => sum up, use symmetry

![Graph showing CIR distribution and analytical vs. openWNS results.]

1 dB Handover Margin

An analytic result compared to an openWNS result for WINNER+ Calibration.

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Wideband SINR [dB]

Org 1, Org 2, Org 3, Org 4, Org 5, Org 6, Org 7, Org 8, Average

[0m,0m] [60m,0m]

Base Station (BS)
CIR Calculation for Indoor Hotspot Scenario

- Integrate over the area and normalize to obtain scenario CIR & rate distribution
- No solution for integral is known => sum up, use symmetry

![Graph showing MCS Index vs. Probability Distribution](image)

- Analytic
- Simulated (500 drops)
- Simulated (50 drops)

Base Station (BS)
LTE Layer 2 Calibration Assumptions

- Data Link Layer (DLL) constrains from ITU-R M.2135:
  - Packets are scheduled with an appropriate packet scheduler(s) [...].
  - Channel quality feedback delay, feedback errors, PDU (protocol data unit) errors and real channel estimation effects inclusive of channel estimation error are modelled and packets are retransmitted as necessary.
  - The overhead channels (i.e., the overhead due to feedback and control channels) should be realistically modelled.

Dowlink:

20 MHz FDD
100 Resource Blocks

10 frames = 1 superframe

Broadcast Control Channel (BCH) every 10 frames
=> Parts of center 6 resource blocks

Specified in [3GPP TR 36.814]
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**Dowlink:**

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- **100 Resource Blocks**

![Dowlink Diagram]

- **10 frames = 1 superframe**
- **Broadcast Control Channel (BCH) every 10 frames**
  - => Parts of center 6 resource blocks
- **Downlink Control Channel (DLCCH) every frame**
  - =>3 of 14 symbols

Specified in [3GPP TR 36.814]
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  =>3 of 14 symbols
Pilot tones: Reduce bit per symbol

Specified in [3GPP TR 36.814]
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20 MHz FDD  
100 Resource Blocks  
9 associated UTs  

Dowlink:  
RoundRobin, full bandwidth allocation  

10 frames = 1 superframe

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20 MHz FDD
100 Resource Blocks
9 associated UTs

Dowlink: RoundRobin, full bandwidth allocation

10 frames = 1 superframe

The number of associated UTs a significantly influences the L2 throughput $T = \frac{r}{a}$

Specified in [3GPP TR 36.814]
Results

\[ T = \frac{r}{a} \]
\[ a \sim \text{Bernoulli}(0.5, 20) \]
\[ P(T) = P(a)P(r) \]
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Throughput \( [\text{bps}] \)

\[ P(x < X) \]

- Analytic
- Simulated (50 drops)
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Throughput [bps]

\[ P(x < X) \]

○ Analytic

● Simulated (1000 drops)
Results

\[ T = \frac{r}{a} \]
\[ a \sim \text{Bernoulli}(0.5, 20) \]
\[ P(T) = P(a)P(r) \]

<table>
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<tr>
<th></th>
<th>Calc.</th>
<th>Sim.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Spectral Efficiency [bit/s/Hz/Cell]</td>
<td>2.269</td>
<td>2.265</td>
</tr>
<tr>
<td>Cell Edge User Spectral Efficiency [bit/s/Hz]</td>
<td>&lt;3</td>
<td>&lt;3</td>
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<tr>
<td>5-Percentile</td>
<td>0.057</td>
<td>0.057</td>
</tr>
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</table>
Summary & Conclusion:

- Layer 2 simulator calibration results have been validated
- openWNS creates correct results under the given assumptions
- See [1] for more

Outlook:

- More than two cells
- Sectorized antennas
- Small scale fading
- MIMO
- **Uplink** => done
- Other partners should validate their simulators

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Thank you for your attention!

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