Zur Leistung von IEEE 802.16m Systemen
17. ComNets-Workshop Mobil- und Telekommunikation

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IMT-Advanced System Evaluation

Performance indicators

IEEE 802.16m protocol
Protocol overhead

Evaluation results
Peak spectral efficiency
Cell spectral efficiency

Conclusion
Performance indicators

VoIP capacity
Number of concurrent served calls

User/Control Plane latency
Delay of user or control plane data

Spectral efficiency
Peak spectral efficiency, cell-edge user spectral efficiency, cell spectral efficiency
Spectral efficiency

- **Peak spectral efficiency**
  Theoretical spectral efficiency of user terminal with best possible link

- **Cell spectral efficiency**
  Mean spectral efficiency for all user terminals in one cell

- **Cell-edge-user spectral efficiency**
  Spectral efficiency of 5% worst performing user terminals

\[ \mu = \frac{T}{B} \]

- **T**: Throughput
- **B**: System bandwidth
Spectral efficiency

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\(T\): Throughput
\(B\): System bandwidth
- **Time domain overhead** \( \nu_t = 10.4\% \)
  - Preamble and synchronization
  - Transmit-Receive Turnaround Gap (TTG) and Receive-Transmit Turnaround Gap (RTG)
  - Cyclic Prefix (CP)

- **Frequency domain overhead** \( \nu_f = 18.2\% \)
  - Guard band DL/UL
  - Pilot subcarrier

- **Tone based overhead** \( \nu_s = 2.68\%...8.6\% \)
  - Super Frame Header (SFH)
  - A-MAP (Resource allocation map)
  - Initial ranging, bandwidth request ranging, CQICH, ARQ feedback channel

- **User data MAC header are not considered in protocol overhead calculation**

**Overall protocol overhead**

\[
1-(1-\nu_t)(1-\nu_f)(1-\nu_s) = 28.75\%...32.95\%
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**Figure: 802.16 TDD Frame**
Time domain overhead $\nu_t = 10.4\%$
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Peak spectral efficiency

- PHY-Mode with highest data rate: 64 QAM, code rate 1
- 4x4 MIMO configuration with MIMO gain 4
- Minimum protocol overhead of 28.75%

<table>
<thead>
<tr>
<th>Duplex mode</th>
<th>Peak DL data rate</th>
<th>Peak UL data rate</th>
<th>Peak DL spectral efficiency</th>
<th>Peak UL spectral efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDD (2 · 20 MHz)</td>
<td>356 Mbit/s</td>
<td>188 Mbit/s</td>
<td>17.8 bit/s·Hz</td>
<td>9.4 bit/s·Hz</td>
</tr>
<tr>
<td>TDD (20 MHz)</td>
<td>169 Mbit/s</td>
<td>92.2 Mbit/s</td>
<td>17.0 bit/s·Hz</td>
<td>9.2 bit/s·Hz</td>
</tr>
</tbody>
</table>
Simulation scenario

Find **upper bound** of cell spectral efficiency through Monte Carlo simulation of ITU-T urban macro scenario

**Table:** Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-site distance</td>
<td>500 m</td>
</tr>
<tr>
<td>BS Tx-Power</td>
<td>49 dBm</td>
</tr>
<tr>
<td>BS antenna tilt</td>
<td>-12°</td>
</tr>
<tr>
<td>System bandwidth</td>
<td>20 MHz</td>
</tr>
<tr>
<td>Sectors per cell</td>
<td>3</td>
</tr>
<tr>
<td>Antenna</td>
<td>directed 120°</td>
</tr>
</tbody>
</table>
TDD DL-SINR

Figure: Distribution of SINR

Figure: PDF of DL-SINR
**Table:** PHY Mode bitrates (20 MHz System bandwidth)

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code</th>
<th>Bitrate $[\text{bit/Hz}]$</th>
<th>min. SINR [dB]$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>CTC 1/2</td>
<td>1.41</td>
<td>2.9</td>
</tr>
<tr>
<td>QPSK</td>
<td>CTC 3/4</td>
<td>2.11</td>
<td>6.3</td>
</tr>
<tr>
<td>16 QAM</td>
<td>CTC 1/2</td>
<td>2.82</td>
<td>8.6</td>
</tr>
<tr>
<td>16 QAM</td>
<td>CTC 3/4</td>
<td>4.23</td>
<td>12.7</td>
</tr>
<tr>
<td>64 QAM</td>
<td>CTC 1/2</td>
<td>4.23</td>
<td>13.8</td>
</tr>
<tr>
<td>64 QAM</td>
<td>CTC 2/3</td>
<td>5.65</td>
<td>16.9</td>
</tr>
<tr>
<td>64 QAM</td>
<td>CTC 3/4</td>
<td>6.35</td>
<td>18</td>
</tr>
<tr>
<td>64 QAM</td>
<td>CTC 5/6</td>
<td>7.07</td>
<td>19</td>
</tr>
</tbody>
</table>

Capacity for SINR below 2.9 dB is approximated with Shannon capacity.

$^1$WiMAX Forum PHY Profile
Figure: CDF of capacity

Cell spectral efficiency

\[ \eta = \frac{1}{B} \left( \frac{1}{A} \int \int_{A} \frac{1}{c(a)} \, da \right)^{-1} \]

- **A**: Cell area
- **B**: System bandwidth
- **c(a)**: Capacity at cell segment **a**

TDD cell spectral efficiency is: 2.48 \text{ bit/s·Hz}

ITU-T requirement is 2.2 \text{ bit/s·Hz}
Conclusion and Outlook

Conclusion

- Spectral efficiency of the 802.16m system meets the ITU-T requirements
- Radio resource management would improve cell capacity

Future work

- Event driven simulative evaluation
  - Channel estimation error in scheduler
  - Consider retransmissions of packet error
- System capacity increase through relay stations
Thank you

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