<table>
<thead>
<tr>
<th>Project</th>
<th>IEEE 802.20 Working Group on Mobile Broadband Wireless Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>MBFDD Performance Report 2 Presentation</td>
</tr>
<tr>
<td>Date Submitted</td>
<td>2006-01-06</td>
</tr>
</tbody>
</table>
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| Re:                           | MBWA Call for Proposals                                      |
| Abstract                      | This contribution (part of the MBFDD proposal package for 802.20), contains the MBFDD Performance Report 2 Presentation slide set. |
| Purpose                       | For consideration of 802.20 in its efforts to adopt an FDD proposal for MBWA. |
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MBFDD Performance Evaluation Report II

Jim Tomcik
jtomcik@qualcomm.com
Outline

• Report II Requirements:
  – Traffic mix simulations.
    • Overhead channel modeling.
    • QoS arbitration.
    • Performance of each individual QoS class.
  – Mobility and handoff

• Performance of Salient Features:
  – Antenna techniques.
    • MIMO Multiple Code Word with Successive Interference Cancellation.
    • Precoding.
  – System enhancements.
    • Quasi-Orthogonal Reverse Link (QORL).
    • Fractional Frequency Reuse (FFR).
    • Spatial Division Multiple Access (SDMA).
Overhead Channel Dimensioning

- Simulated a packet-by-packet scheduler to generate assignment statistics.
- SSCH dimension: 12 total assignments, power control bits for 200 users, and ACK/NACK for 30 RL channels $\Rightarrow$ 22% FL overhead.
- Resource utilization is shown not to be affected by 8 FLAB constraints.
- Typical scheduling load is much less than the maximum dimension.
# Traffic Mix Assumptions

<table>
<thead>
<tr>
<th></th>
<th>FL Evaluation</th>
<th>RL Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>QoS Admission Control</td>
<td>30-30-30-10% Per-sector FTP-HTTP-NRTV-VOIP</td>
<td>VOIP</td>
</tr>
<tr>
<td>TCP Packet Size</td>
<td>1500 bytes</td>
<td>N/A</td>
</tr>
<tr>
<td>Maximum RLP Transmissions</td>
<td>1(VOIP), 2(Others)</td>
<td>1</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>5:00 minutes</td>
<td>5:00 minutes</td>
</tr>
</tbody>
</table>
Channel Mix Test

- Channel models:
  - Suburban macro pedB 3 Km/h
  - Suburban macro vehB 120 Km/h
  - Suburban macro mix.
  - Urban micro mix.
- 19 cell wrap-around layout.
- Traffic mix:
  - 30-30-30-10
  - 10 users per sector.
- Conclusions:
  - Served data rate matches the offered data rate.
  - Different channel models have similar performances.
Fairness Among BE Flows

• Simulation setup:
  – Suburban macro mix.
  – Loading level: 80 users/sector
  – EF and AF flows is scheduled with higher priority than the BE flows.
  – Proportional fairness is enforced among BE flows.

• Conclusion:
  – BE flows meet the 802.20 fairness.
Latency vs. Load

- Flows with QoS reservation:
  - Mean latency of VOIP and NRTV satisfy QoS for all loading level.
- Best effort flows:
  - HTTP and FTP latency increases as load increases.
Download Speed vs. Load

- Simulation setup:
  - SIMO 1x2
- Light loading at 20 users per sector
  - FTP: 3 Mbps.
  - HTTP: 500 Kbps.
- Heavy loading
  - FTP and HTTP rate reduces significantly for more than 100 users per sector.
MIMO Download Speed

• Simulation setup:
  – MIMO 4x4 with single codeword decoding and linear MMSE receiver.
• MIMO 4x4 @160 users/sector has better FTP/HTTP download speed than SIMO 1x2 system @ 60 users/sector.
NRTV Availability

- NRVT availability is defined as the percentage of NRTV packets of a user that are not in outage condition (> 5 sec delay).
Voice Latency vs. Load

- RL voice traffic is simulated with 20 voice users/sector to approximate the RL traffic of a 200 users/sector with the specified traffic mix.
- Maximum FL mean user latency is less than 12 ms @ 180 users/sector.
FL Voice E-Model Score

- User mean PER tail increases as load increases.
- E-Model score reflects the packet errors experienced by users in poor channel condition.
RL Voice E-Model Score

- User PER distributions are similar for different channel models.
- E-Model score reflects the packet errors experienced by users in poor channel condition.
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    • Spatial Division Multiple Access (SDMA).
Mobility and Handoff

- Handoff decision
  - FL: based on FL pilot measurements
  - RL: based on R-CQICH erasure indicators
- Handoff indication to the desired sector
  - FL: using R-CQICH
  - RL: using R-REQCH
- Handoff completion
  - When AT receives assignment from the new sector
Outage and Connection Drop

- Current serving sector continues to serve the terminal during L1 handoff signaling (and even part of L2 handoff negotiation).
- Outage may happen only during FL handoff (inter-cell).
- Outage period is equal to one-way backhaul delay.
- Connection drop probability is practically zero.
## Mobility Simulation Models

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Interpretation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Site-to-site distance</td>
<td>1000 m</td>
</tr>
<tr>
<td>EdgeLoss</td>
<td>Sudden propagation loss at cell edge for model 2</td>
<td>3, 6, 9 dB</td>
</tr>
<tr>
<td>V</td>
<td>Mobile Speed</td>
<td>3, 30, 120 Km/h</td>
</tr>
<tr>
<td>$D_{corr}$</td>
<td>Shadow Fading Corr. Distance</td>
<td>30 m</td>
</tr>
<tr>
<td>$D_0$</td>
<td>Distance of starting point from A in paths 1 and 2 (same as distance of ending point from B)</td>
<td>30 m</td>
</tr>
<tr>
<td>$D_3$</td>
<td>Total distance covered by terminal in path 3</td>
<td>1000 m</td>
</tr>
<tr>
<td>FilterTimeConstant</td>
<td>SINR and C/I filter time constant for active set management and handoff decision</td>
<td>100 msec</td>
</tr>
<tr>
<td>AddThreshold</td>
<td>Active set add threshold (on filtered SINR)</td>
<td>-7 dB</td>
</tr>
<tr>
<td>DropThreshold</td>
<td>Active set drop threshold (on filtered SINR)</td>
<td>-9 dB</td>
</tr>
<tr>
<td>DropTimer</td>
<td>Active set drop timer (if the SINR of an active set sector remains below DropThreshold for this period, it is dropped from the active set.)</td>
<td>2 sec</td>
</tr>
<tr>
<td>FLHandoffHysteresis</td>
<td>Forward link handoff hysteresis (on filtered effective C/I)</td>
<td>2 dB</td>
</tr>
<tr>
<td>RLHandoffHysteresis</td>
<td>Reverse link handoff hysteresis (on CQI erasure indicator rate)</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Mobility Simulations, Model 2

Geometry trace for Active Sectors: Model 2, 3dB Edge Loss

Filtered Effective C/I Trace for Active Sectors, Model 2, 3dB Edge Loss

- Sector 38
- Sector 20
- Sector 0
- Sector 26
- Sector 38
- Sector 40
- Sector 41
- Sector 49
Handoff Delay Distributions

**FL Handoff Delay**
- Intra-Cell, Avg. = 8.9 msec
- Inter-Cell, Avg. = 27.1 msec
- Overall, Avg. = 25.7 msec

**RL Handoff Delay**
- Intra-Cell, Avg. = 9.3 msec
- Inter-Cell, Avg. = 10.2 msec
- Overall, Avg. = 10.1 msec
Idle State Performance

• Duty cycle in idle state
  – Required to read 8 OFDM symbols every page period

<table>
<thead>
<tr>
<th>Paging period in superframes</th>
<th>Paging period in seconds</th>
<th>Duty Cycle (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.04588</td>
<td>2.3</td>
</tr>
<tr>
<td>16</td>
<td>0.367</td>
<td>0.29</td>
</tr>
<tr>
<td>64</td>
<td>1.468</td>
<td>0.072</td>
</tr>
<tr>
<td>128</td>
<td>2.94</td>
<td>0.036</td>
</tr>
</tbody>
</table>

• Access delay
  – Access opportunity occurs every six frames (5.5msec)

• Paging overhead: 1.55%
  – Assuming 20 pages/second/sector, 5 MHz system
  – QuickPage: 1.25% and Paging on traffic channel: 0.3%
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    • Fractional Frequency Reuse (FFR).
    • Spatial Division Multiple Access (SDMA).
**MCW vs. SCW**

- Performance captures rate prediction, HARQ, coding and channel estimation performance.
- Channel model: pedB@3km/hr,
- Spatial correlation:
  - Suburban macro, AoD: 50 degree; AS: 2 degree,
  - Antenna configuration: 4x4 with 10 λ spacing at AP and 0.5 λ spacing at AT.
FDD MIMO Precoding Capacity Study

- Gap to capacity 3 dB to model coding and channel estimation loss.
- Precoding codebook size: 64
- Feedback over 5 MHz channel.
- Channel model: pedB@3km/hr;
- No spatial correlation, antenna configuration: 4x2
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Simulation Numerology

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth of Operation</td>
<td>5MHz</td>
</tr>
<tr>
<td>FFT Size</td>
<td>512</td>
</tr>
<tr>
<td>Chip rate</td>
<td>4.9152Mcps</td>
</tr>
<tr>
<td>Subcarrier spacing</td>
<td>9.6kHz</td>
</tr>
<tr>
<td>Guard carriers</td>
<td>32 subcarriers</td>
</tr>
<tr>
<td>Cyclic Prefix</td>
<td>6.51 μs</td>
</tr>
<tr>
<td>Windowing Duration</td>
<td>3.26 μs</td>
</tr>
<tr>
<td>OFDM Symbol Duration (For 6.51μs CP)</td>
<td>113.93 μs</td>
</tr>
</tbody>
</table>
Quasi-Orthogonal Reverse Link

- Antenna configuration: 1x4 (diversity antennas)
- Channel model: pedB@3km/h, vehA@30km/h.
- Spatial correlation: urban micro (500m site-to-site distance).
- MMSE
  - Estimate spatial structure of all intra-sector users.
  - Additional estimation loss due to QORL is modeled.
  - Other sector interference is modeled as spatially uncorrelated.
- Results are conservative
  - Same multiplexing order for all users.
  - No user clustering has been implemented in simulations.

<table>
<thead>
<tr>
<th>Sector (Kbps)</th>
<th>Throughput</th>
<th>Q = 1</th>
<th>Q = 2</th>
<th>QORL Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>PedB at 3 Km/h</td>
<td>5716</td>
<td>7251</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>VehA at 30 Km/h</td>
<td>5646</td>
<td>6990</td>
<td>24%</td>
<td></td>
</tr>
</tbody>
</table>
Fractional Frequency Reuse

- 300 meters site-to-site distance, urban micro propagation loss.

<table>
<thead>
<tr>
<th>FFR Results for FDD</th>
<th>Throughput (kbps)</th>
<th>%-change Throughput</th>
<th>5%-Spectral Eff (bps/Hz)</th>
<th>%-change 5%-Spec Eff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x1, EGOS, baseline</td>
<td>2985</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x1, EGOS, PL 10%</td>
<td>3090</td>
<td>3.52</td>
<td>0.31</td>
<td>3.33</td>
</tr>
<tr>
<td>1x1, EGOS, PL 20%</td>
<td>3197</td>
<td>7.10</td>
<td>0.39</td>
<td>30.00</td>
</tr>
<tr>
<td>1x1, EGOS, PL 27%</td>
<td>3210</td>
<td>7.54</td>
<td>0.44</td>
<td>46.67</td>
</tr>
<tr>
<td>1x1, EGOS, PL 50%</td>
<td>3180</td>
<td>6.53</td>
<td>0.69</td>
<td>130.00</td>
</tr>
<tr>
<td>1x1, PF, baseline</td>
<td>5087</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x1, PF, PL 10%</td>
<td>5520</td>
<td>8.51</td>
<td>0.48</td>
<td>37.14</td>
</tr>
<tr>
<td>1x1, PF, PL 20%</td>
<td>5343</td>
<td>5.03</td>
<td>0.56</td>
<td>60.00</td>
</tr>
<tr>
<td>1x1, PF, PL 27%</td>
<td>5387</td>
<td>5.90</td>
<td>0.61</td>
<td>74.29</td>
</tr>
<tr>
<td>1x1, PF, PL 50%</td>
<td>4821</td>
<td>-5.23</td>
<td>0.90</td>
<td>157.14</td>
</tr>
<tr>
<td>1x2, EGOS, baseline</td>
<td>4779</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x2, EGOS, PL 10%</td>
<td>5122</td>
<td>7.18</td>
<td>0.68</td>
<td>13.33</td>
</tr>
<tr>
<td>1x2, EGOS, PL 20%</td>
<td>5075</td>
<td>6.19</td>
<td>0.80</td>
<td>33.33</td>
</tr>
<tr>
<td>1x2, EGOS, PL 27%</td>
<td>5045</td>
<td>5.57</td>
<td>0.83</td>
<td>38.33</td>
</tr>
<tr>
<td>1x2, EGOS, PL 50%</td>
<td>4707</td>
<td>-1.51</td>
<td>1.27</td>
<td>111.67</td>
</tr>
<tr>
<td>1x2, PF, baseline</td>
<td>6853</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x2, PF, PL 10%</td>
<td>7350</td>
<td>7.25</td>
<td>0.77</td>
<td>28.33</td>
</tr>
<tr>
<td>1x2, PF, PL 20%</td>
<td>7155</td>
<td>4.41</td>
<td>0.85</td>
<td>41.67</td>
</tr>
<tr>
<td>1x2, PF, PL 27%</td>
<td>7086</td>
<td>3.40</td>
<td>0.94</td>
<td>56.67</td>
</tr>
<tr>
<td>1x2, PF, PL 50%</td>
<td>6028</td>
<td>-12.04</td>
<td>1.47</td>
<td>145.00</td>
</tr>
</tbody>
</table>
FL SDMA

- Channel model: pedB@ 3km/h.
- Spatial correlation: suburban macro.
- Codebook size: 2
- Users select one beam at the beginning of each simulation run.
- MMSE: spatial processing based on estimate of spatial structure of intra-sector and inter-sector interference.

<table>
<thead>
<tr>
<th>Sector Throughput (Kbps) and Gain over Baseline System</th>
<th>SDMA</th>
<th>Baseline FDD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4x2</td>
<td>1x2</td>
</tr>
<tr>
<td></td>
<td>4x4</td>
<td>1x4</td>
</tr>
<tr>
<td></td>
<td>0.5λ</td>
<td>1x2</td>
</tr>
<tr>
<td></td>
<td>0.5λ</td>
<td>1x4</td>
</tr>
<tr>
<td></td>
<td>MRC</td>
<td>MRC</td>
</tr>
<tr>
<td></td>
<td>MMSE</td>
<td>MMSE</td>
</tr>
<tr>
<td>1km BS to BS Suburban Macro PedB 3km/h</td>
<td>8709 (47%)</td>
<td>10431 (76%)</td>
</tr>
<tr>
<td></td>
<td>11571 (49%)</td>
<td>15155 (96%)</td>
</tr>
<tr>
<td></td>
<td>5912</td>
<td>7740</td>
</tr>
</tbody>
</table>