Multiband OFDM for UWB Communication: Analysis and Extensions

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Agenda

- What is UWB?
- Multiband OFDM proposal for high data-rate UWB
- Our research in Multiband OFDM at UBC
  - How good is the standard?
  - How can we improve it?
  - Impact of interference?
  - Tools for analysis and design
- Future research directions
Ultra-Wideband (UWB) Wireless Transmission

- UWB is a wireless technology that uses an ultra-wide bandwidth (> 500 MHz) and operates at very low power
- Underlay (reuse spectrum, potential for interference)
- FCC: license-exempt operation in 3.1–10.6 GHz band
UWB — Multiband OFDM

- Multiband OFDM: leading proposal for high-rate UWB
- First-gen: use three 528 MHz bands in 3.1–4.8 GHz

- Data rates between 55 and 480 Mbps
- Frequency hopping (simultaneously operating piconets)

- Will be used in Wireless USB, Wireless 1394 (Firewire)
Contributions: How good is the PHY Layer?

- Standard proposal close to corresponding theoretical limit...
Contributions: PHY Layer Improvements

- Our extensions: improvement by up to 5 dB!
## Contributions: PHY Layer Improvements

<table>
<thead>
<tr>
<th>System</th>
<th>$10 \log_{10}(\bar{E}_s/N_0)$</th>
<th>Gain (dB)</th>
<th>% range increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC, no loading (Standard Proposal)</td>
<td>18.76</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CC, CCB loading</td>
<td>15.38</td>
<td>3.38</td>
<td>47 %</td>
</tr>
<tr>
<td>CC, $D = 2$ clustered loading</td>
<td>15.47</td>
<td>3.29</td>
<td>46 %</td>
</tr>
<tr>
<td>TC, no loading</td>
<td>14.09</td>
<td>4.67</td>
<td>71 %</td>
</tr>
<tr>
<td>TC, CCB loading</td>
<td>12.48</td>
<td>6.28</td>
<td>106 %</td>
</tr>
<tr>
<td>TC, $D = 2$ clustered loading</td>
<td>12.58</td>
<td>6.18</td>
<td>103 %</td>
</tr>
</tbody>
</table>

(Assumptions: UWB Channel CM1, 480 Mbps, free space path loss exponent, $\text{BER} \leq 10^{-5}$ for the 90% best channel realizations)
Contributions: Error Bounds

• We have a method to accurately predict the error rates of coded Multiband OFDM systems.

• Much faster than simulation.
• Narrowband interference may have a large effect on Multiband OFDM...
• We can compensate with erasure decoding.
Future Work

- More complex interference models
- Cognitive Radio
  - Smart spectrum usage
  - Detect and avoid narrowband systems — will be required in Japan (and Europe ?)
  - Intelligent radios → better performance!
- New schemes to enhance Multiband OFDM system
Conclusions

- Multiband OFDM: an excellent technology for Wireless PANs
- We have made contributions in
  - Performance analysis (limits, actual performance)
  - System enhancements
  - Effect of interference
- More to come!

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