Proposal for 5-GHz PHY

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Key Features

- Wide Transmission Bandwidth
- Noncoherent 4 x 4-ary BiOrthogonal Signaling
- MSK Spreading Modulation
- 16 Chips/Symbol
- Changing PN Codes
- “Good” PN Codes
- Minimal Acquisition Time
- Low E_b/N_0
- Saturated Power Amplifier
- Spectral Confinement
- Power-Efficient Transmission
- Code Channelization

System
- Robust Links
- High Throughput
- Low Battery Drain
- Overlapped BSAs
Robust Links

- Resolving paths gives more independent trials
- Reduced strength per path, but
- Low probability that all fade
- D11-97/119 demonstrates for diffuse Rayleigh
- Even better with specular multipath

- Functional processing gain (PG) of 12 dB
- Probably required as the UNII band fills up
Robust Links

- Test with specular multipath, without noise
  - must consider crosscorrelation side lobes
- D11-97/117 documents preferred 16-bit codes
  - best 8 of 2048 cosets
- Must analyze self-interference with sum of four

Robust Links

- Repeated spreading code correlates with far-out multipath
  - strong intersymbol interference (ISI)
- Use 4 cosets cyclically
  - no correlated ISI for four symbols
- Could use 8 cosets, but
  - not really needed
  - better to have 2 groups of 4 codes for spatial re-use
High Throughput

Noncoherent 4 x 4-ary BiOrthogonal Signaling

“Good” PN Codes

24/18-Mbps Data Rate

Low Preamble Overhead

High Throughput

12 bits/symbol with 6-dB peak/average envelope

9 bits/symbol constrains the modulator to constant envelope!
Examples of Tx Waveforms

Throughput

- Noncoherent: no PLL, no settling time
- Good PN codes: no equalizer, no adaptation time
- DPSK on SFD & SIGNAL: no CRC required

High Throughput

PHY header ~20 µs

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<td>W10</td>
<td>W15</td>
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Throughput vs. Frame Size

- 24 Mbps
- 18 Mbps
- 10 Mbps

High Throughput

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Throughput (Mbps) vs. Frame Size (Bytes)
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Power Efficiency

- Exploits bandwidth for robustness
- 9.3 to 10.5 dB $E_b/N_0$ for $10^{-6} P_{SE}$
- Similar in efficiency to DPSK

**MSK allows operation into power-amp saturation**
- constrained-amplitude mode only
- 9 bits/symbol
- but 6-dB greater average power
- PA efficiency greatly improves

**D11-97/118** describes generation and performance
Channelization and Coexistence

- MSK\(^1\) (or MSK shaping) enhances channelization
- 32-Mchip/s
  - two wideband\(^2\) per 100-MHz
- options if 16-Mchip/s
  - a wideband and two narrowband\(^3\) per 100-MHz
  - four narrowband per 100-MHz
- 108 to 144 Mbps capacity in 6 to 12 frequency channels

\(^1\) D11-97/118 describes MSK generation  \(^2\) wideband = 24 or 18 Mbps  \(^3\) narrowband = 12 or 9 Mbps

Channelization and Coexistence

- Selected best 8 codes (of 2048) for demodulating data in multipath
- Selected best 8 codes for preamble search (and acquisition) in multipath
- Mutual rejection much better than “random” implied by processing gain
- Many strategies for code assignment
  - unique pairing of data/search codes gives 8 code channels
  - arbitrary pairing of data/search codes gives 64 code channels
  - intra-frame code changing greatly expands the possibilities
- Can be combined with six to twelve frequency channels

D11-97/117 describes data codes
Summary of Possible Data Modes

<table>
<thead>
<tr>
<th>Chip Rate</th>
<th>Modulation Option</th>
<th>Data Rate</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 MHz(^1)</td>
<td>16-ary BiOrthogonal</td>
<td>10 Mbps</td>
<td>-92 dBm</td>
</tr>
<tr>
<td></td>
<td>4 x 4-ary BiOrthogonal (constrained(^3))</td>
<td>18 Mbps</td>
<td>-86 dBm(^4)</td>
</tr>
<tr>
<td></td>
<td>4 x 4-ary BiOrthogonal</td>
<td>24 Mbps</td>
<td>-86 dBm</td>
</tr>
<tr>
<td>16 MHz(^2)</td>
<td>16-ary BiOrthogonal</td>
<td>5 Mbps</td>
<td>-95 dBm</td>
</tr>
<tr>
<td></td>
<td>4 x 4-ary BiOrthogonal (constrained)</td>
<td>9 Mbps</td>
<td>-89 dBm(^5)</td>
</tr>
<tr>
<td></td>
<td>4 x 4-ary BiOrthogonal</td>
<td>12 Mbps</td>
<td>-89 dBm</td>
</tr>
</tbody>
</table>

\(^1\) six total channels in UNII band  \(^2\) twelve total channels in UNII band  
\(^3\) constant envelope MSK  \(^4\) average transmitter power increases by 6 dB

\(^5\) constant envelope MSK