Proposal for an OFDM based 802.16.3 Air Interface Physical Layer

IEEE 802.16 Presentation Submission Template (Rev. 8)

Document Number: IEEE 802.16.3p-00/44
Date Submitted: 2000-11-08

Source:

Jose Francia
Voice:  +34 91 330 4679
Alcatel
Fax:  +34 91 330 5082
Ramirez de Prado, 5
E-mail: veq@alcatel.es
Madrid

Venue:

802.16. Session # 10Tampa,FL Nov. 2000

Base Document:

<http://grouper.ieee.org/groups/802/16/tg3/contrib/802163c-00_44.pdf>

Purpose:

802.16.3 PHY proposal for presentation, discussion and decision

Notice:

This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate text contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

IEEE 802.16 Patent Policy:

The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures (Version 1.0) <http://ieee802.org/16/ipr/patents/policy.html>, including the statement “IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard.”

Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:r.b.marks@ieee.org> as early as possible, in written or electronic form, of any patents (granted or under application) that may cover technology that is under consideration by or has been approved by IEEE 802.16. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/letters>.
Basics

- Based on HiperLAN2, 802.11a
- TDD and FDD duplexing modes
- Burst format
- OFDM as multiplexing/transmission technique
- TDMA as Multiple Access Technique
- Open to improvements/add-ons
Conceptual PHY Block Diagram

Transmitter:
- Scrambler
- FEC Convol. Coder/Punct
- Block Interleaver
- QAM Mapping
- OFDM IFFT.
- Cyclic Prefix & Filter
  - DAC
  - RF Tx

Receiver:
- Descrambler
- Depunct/FEC Decoder
- Block Deinterleav
- QAM Demapp
- OFDM FFT.
- Cyclic Prefix Removal
  - RF Rx
  - Timing
  - ADC
Main (OFDM) parameters

- Channel spacings conforming to F.R.D.
- 52 subcarriers with variable spacing
- 48 data carrying subcarriers and 4 pilot subcarriers for carrier phase reference.
- QPSK, 16-QAM, 64QAM modulation on each subcarrier with Gray-coded constellation mapping
- Block interleaver with block size equal to a single OFDM symbol.
- K=7, R=1/2 industry standard convolutional code with puncturing to rates of R= 9/16 and 3/4.
- Variable OFDM symbol duration according to channel width.
Example of numerical values of OFDM Parameters

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>3.5</th>
<th>3</th>
<th>1.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Channel (MHz)</td>
<td>B</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>3.5</td>
<td>3</td>
<td>1.75</td>
</tr>
<tr>
<td>Sampling rate 1/T (MHz)</td>
<td>B</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>3.5</td>
<td>3</td>
<td>1.75</td>
</tr>
<tr>
<td>FFT size N</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Subcarrier spacing fc (KHz)</td>
<td>B/64</td>
<td>109,375</td>
<td>93,75</td>
<td>78,125</td>
<td>54,688</td>
<td>46,875</td>
<td>27,344</td>
</tr>
<tr>
<td>FFT time Tc (µs)</td>
<td>64 x T</td>
<td>9,143</td>
<td>10,667</td>
<td>12,800</td>
<td>18,286</td>
<td>21,333</td>
<td>36,571</td>
</tr>
<tr>
<td>Cyclic prefix time Tp (µs)</td>
<td>16 x T</td>
<td>2,286</td>
<td>2,667</td>
<td>3,200</td>
<td>4,571</td>
<td>5,333</td>
<td>9,143</td>
</tr>
<tr>
<td>Symbol duration Ts (µs)</td>
<td>80 x T</td>
<td>11,429</td>
<td>13,333</td>
<td>16,000</td>
<td>22,857</td>
<td>26,667</td>
<td>45,714</td>
</tr>
<tr>
<td>Symbol rate fs (Ksym/s)</td>
<td>1 / Ts</td>
<td>87,500</td>
<td>75,000</td>
<td>62,500</td>
<td>43,750</td>
<td>37,500</td>
<td>21,875</td>
</tr>
<tr>
<td>Number of data subcarriers</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Number of pilot subcarriers</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total number of subcarriers</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Occupied BW (KHz)</td>
<td>53 x fc</td>
<td>5797</td>
<td>4969</td>
<td>4141</td>
<td>2898</td>
<td>2484</td>
<td>1449</td>
</tr>
</tbody>
</table>
Example of Burst & Preamble Structure

Variable burst size, variable preamble
## Summary of Physical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomization</td>
<td>$1 + X^4 + X^7$</td>
</tr>
<tr>
<td>Modulation</td>
<td>QPSK, 16-QAM, or 64-QAM.</td>
</tr>
<tr>
<td>Spectral shaping</td>
<td>Done in the time domain.</td>
</tr>
<tr>
<td>Interleaving block size:</td>
<td>One OFDM symbol.</td>
</tr>
<tr>
<td>OFDM FFT size</td>
<td>64</td>
</tr>
<tr>
<td>Number of subcarriers</td>
<td>48 data + 4 pilots</td>
</tr>
<tr>
<td>Preamble length:</td>
<td>Variable, up to 4Ts</td>
</tr>
</tbody>
</table>
### Available Bit Rates for a 7 MHz RF channel

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Symbol rate (Mbaud/s)</th>
<th>Coded bit rate (Mbit/s)</th>
<th>Code rate</th>
<th>Payload bit rate (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>4.2</td>
<td>8.4</td>
<td>1 / 2</td>
<td>4.2</td>
</tr>
<tr>
<td>QPSK</td>
<td>4.2</td>
<td>8.4</td>
<td>3 / 4</td>
<td>6.3</td>
</tr>
<tr>
<td>16QAM</td>
<td>4.2</td>
<td>16.8</td>
<td>9 / 16</td>
<td>9.45</td>
</tr>
<tr>
<td>16QAM</td>
<td>4.2</td>
<td>16.8</td>
<td>3 / 4</td>
<td>12.6</td>
</tr>
<tr>
<td>64QAM</td>
<td>4.2</td>
<td>25.2</td>
<td>3 / 4</td>
<td>18.9</td>
</tr>
</tbody>
</table>
Addressing the Evaluation Criteria

- Very first estimations given:
  - 2.71 bits/sec/Hz (user information)@ 7 MHz channel
  - System gain: 98–118 dB (NF 6 dB, IL 2 dB, 23 dBm)
  - Adjacent Channel Rejection
  - Transmit Mask
  - PA back-off: 7–9 dB (w/o PAPR mitigacion techniques)
  - Phase noise -70 dBc/Hz at 10 KHz offset @ 1.75 MHz
  - Frequency stability: 2 ppm @ 1.75 MHz