Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Amber proposal for 802.16 PHY layer**
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Re:	Response to a Call for Contributions, 802.16 PHY layer, from Sep. 22
Abstract	This document is a draft specification of a multi-rate quadrature amplitude modulation (QAM) scheme for broadband wireless access PHY.
Purpose	Adoption of this draft as the basis for the broadband wireless access PHY
Notice	
Release	
IEEE Patent Policy	

AMBER proposal for 802.16 PHY layer

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1. Overview

This documents describes a proposal for the PHY layer of the 802.16, in accordance with the “Development Plan for the 802.16.1 Air Interface Standard" (Document IEEE 802.16-99/05).

The proposed PHY describes an 12.29Mbps to 65.54Mbps physical layer based on QAM modulation in the 10 – 66GHz frequency band.

The proposed PHY is based on multi-rate QAM scheme. The proposed channel width is 10MHz, and the proposed symbol rate is 8.192Mbaud. Modulation rates vary from 4-QAM to 256-QAM. With 4-QAM being mandatory and all other rates being optional. The modulation is complemented by a TCM coding scheme with code rates from 3/4 to 7/8. Support for the error correction scheme is mandatory, but ECC can be turned on or off on a per packet basis.

The proposed PHY allows implementers a wide range of combinations of simplicity, robustness and spectral efficiency. The proposed channel width is narrow enough to allow usage and flexible cellular deployment in frequency bands with limited frequency allocations.

2. Reference model

The PHY described in this document can be used for both the CPE and BTS modems. It supports transmission and reception of variable length packets.

In the transmit direction the PHY receives from the MAC the data packet header which describes transmission characteristics such as modulation rate, packet length, error correction scheme. The PHY also receives the data packet itself, and transmit timing information.

In the receive direction the MAC receives from the PHY the data packet header, the packet itself, and reception timing information. The timing information allows the CPE modem to synchronize its timing to the BTS modem. A block diagram of the connections between MAC, PHY and radio is shown bellow.

The MAC controls radio parameters such as transmit power, and receives signal strength indication from the radio receiver.

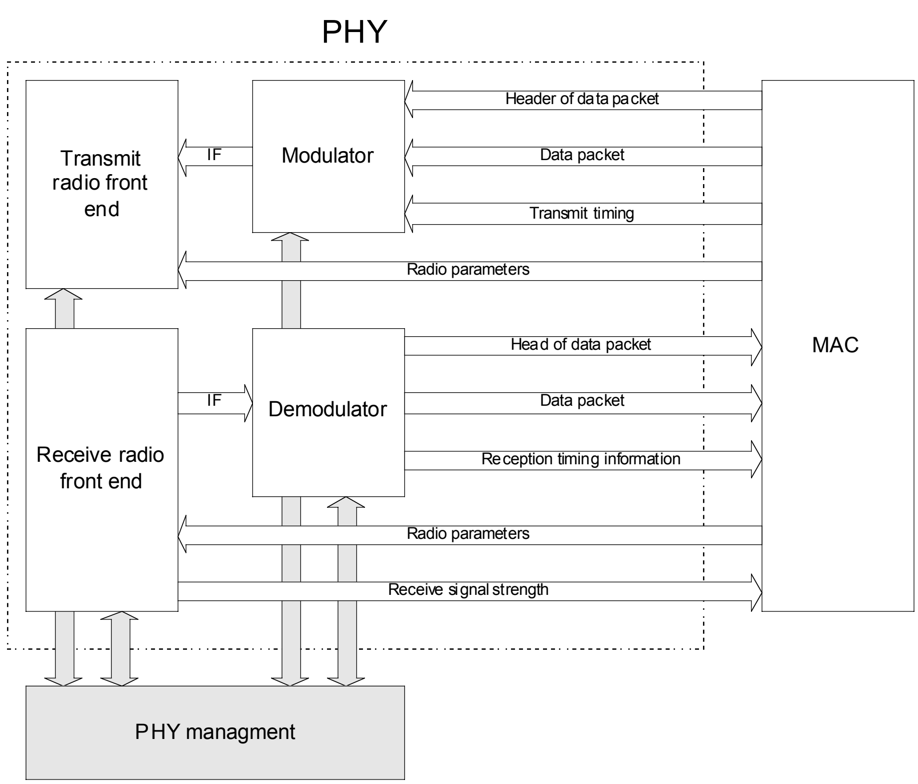

Figure 1. PHY reference model

2.1. Transmitter block diagram

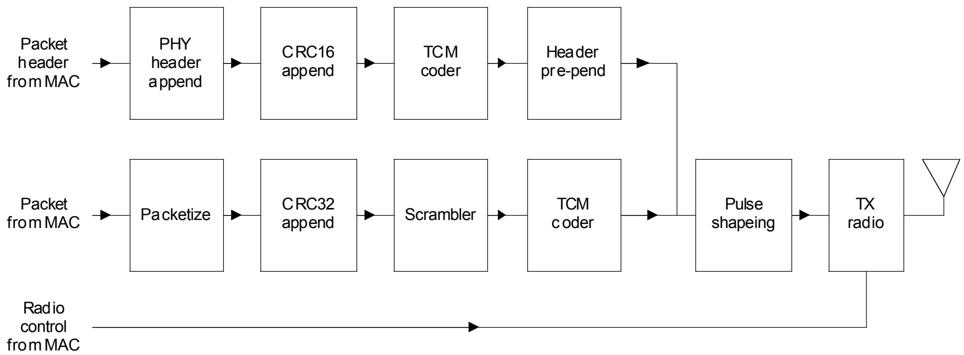

Figure 2. PHY transmit path

2.2. Receiver block diagram

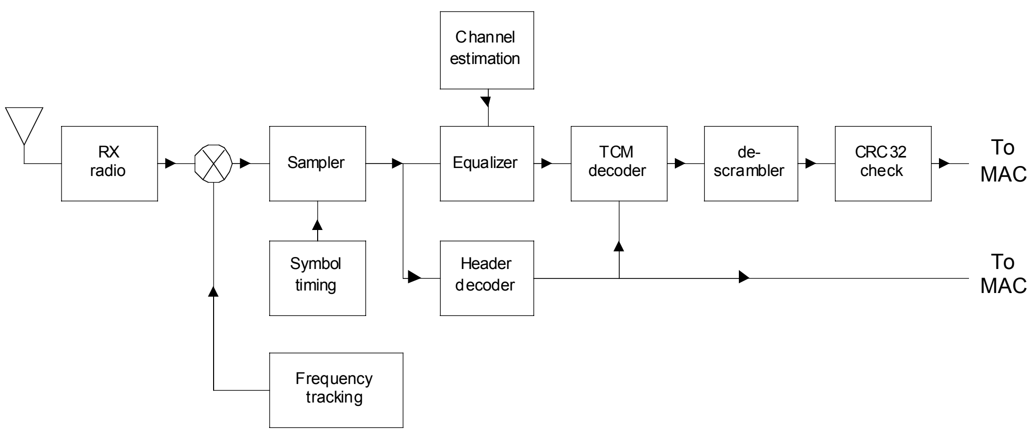

Figure 3. PHY receive path

3. PHY Services

3.1. RF Channelization

3.1.1. Target Spectrum

TBD.

3.1.2. Channel definition

The proposed channel width is 10MHz. Exact channel mask TBD.

3.1.3. Accuracy and Stability

The assigned channel frequency tolerance MUST not exceed ±15 parts per million over a temperature range of –40 to 75 degrees Celsius up to five years from date of manufacture.

3.1.4. Carrier Phase Noise

The transmitter total phase noise integrated over the entire spectrum excluding a 2KHz band centered on the carrier MUST be less than or equal to -28dBc.

3.2. Duplexing Mode

3.2.1. FDD/TDD

The proposed PHY can be used in either TDD or FDD duplexing mode.

3.2.1. Frame Structure

The following general packet structure is proposed,

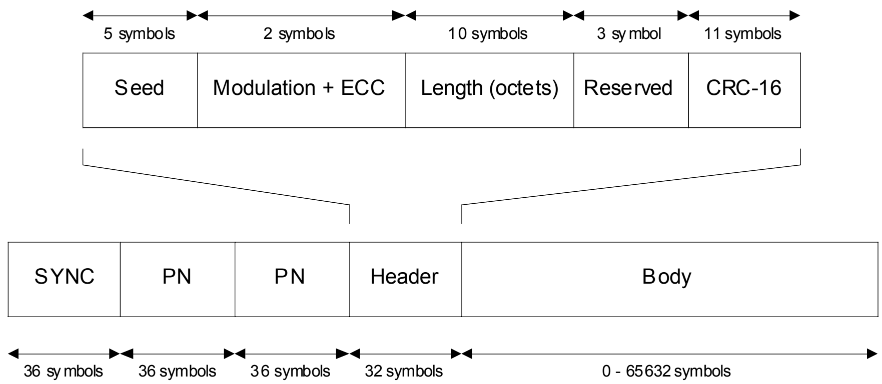

Figure 4. PHY frame format

The packet contains several fields,

SYNC – For frequency offset and symbol timing estimation

PN – A pseudo-noise sequence for locating the start of the packet

HEADER – Transmitted using 4-QAM modulation, and therefore understandable by all modems. The header describers the modulation, ECC scheme and packet length used for the packet body.

BODY – The actual packet to transmit as specified by the header

4. Transmission

4.1.1. Transmission Power Levels

The transmit radio MUST support varying the amount of transmit power. The minimum power control range should be -30dBm to +10 dBm, in 2dB steps.

4.1.2. Attack/Release Time

Packet attack to within 2dB of full power, and release from within 2dB of full power to 50dB bellow full power, MUST be less than $1\mu Sec$.

4.1.3. Modulation Scheme

The modulator MUST provide 4-QAM modulation rate. Other modulation rates such as 16-QAM, 64-QAM and 256-QAM are optional. The modulator symbol rate should be 8.192Msym/Sec. The modulation mode (4-QAM and beyond) can be set on a packet by packet basis. The modulator should use a Nyquist square root raised cosine filter with maximum 22% roll-off.

4.1.4. Symbol Rate Accuracy

The symbol timing tolerance MUST not exceed ±15 parts per million over a temperature range of -5 to 45 degrees Celsius up to five years from date of manufacture.

4.2. Scrambler

The polynomial $G(z) = z^7 + z^4 + 1$ MUST be used to scramble all bits transmitted by the PHY, starting from the MODULATION field in the packet header. The same scrambler is used to scramble transmit data and to descramble receive data. When transmitting, the initial state of the scrambler will be set to a pseudo random non-zero state. The bits of the SEED field will be set to all zeros prior to scrambling in order to enable estimation of the initial state of the scrambler in the receiver. Typical implementation of the scrambler is shown bellow,

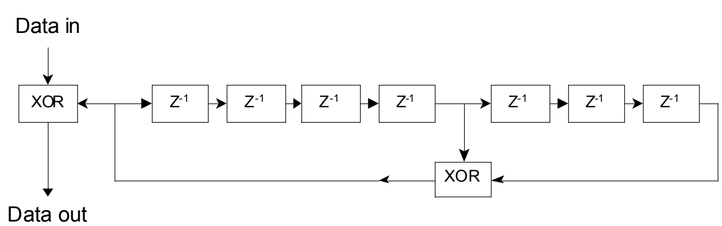

Figure 5. PHY scrambler/de-scrambler

4.2.1. FEC

The modulator MUST support an eight-state TCM based error correction scheme. The ECC can be activated or deactivated on a per packet basis, based on the link conditions. The code polynomials and signal mapper are TBD.

4.2.2. Spurious Emissions

TBD

5. Reception

5.1. Reference Set-up and Test Conditions

5.2. Minimum Performance Requirement

5.2.1. BER

The 4-QAM demodulator must achieve a post FEC BER of 10^{-6} or better at a carrier to noise ratio (C/N) of 10dB or less.

5.2.2. Adjacent Channel Rejection

The 4-QAM demodulator must achieve a post FEC BER of 10^{-6} or better with an interfering modulated carrier present in the adjacent channel, at a carrier to interference ratio (C/I) of 0dB or less.

5.2.3. Co-channel Rejection

The 4-QAM demodulator must achieve a post FEC BER of 10^{-6} or better with an interfering modulated carrier present in the same channel, at a carrier to interference ratio (C/I) of 10dB or less.

6. PHY Procedures

6.1. Time synchronization

TBD

6.2. Frequency synchronization

TBD

6.3. Signal level Measurement

TBD

6.4. Packet reception

TBD

7. Expected Deployment Scenario

TBD

8. Benefits of proposed PHY

1. Support for multi-rate modulation enhances system robustness to interference, and channel impairments.
2. Support of high order modulations allows efficient spectrum usage up to 5.8bits/Sec/Hz when link conditions allow it.
3. TCM coding achieves high coding gain with a simple and easy to implement decoder.
4. Allows implementers a wide range of combinations of simplicity, robustness and spectral efficiency.
5. The relatively narrow channel width allows usage and flexible cellular deployment in frequency bands with limited frequency allocations. The PHY can be adapted to other channel widths by scaling its symbol rate.
6. Optional usage of an equalizer enhances robustness against channel impairments.
7. Reference system gain for 4-QAM will be 120dB, assuming a 0dBW transmitter, an ideal LNA (0dB NF), 4dB backoff for the transmitter power amplifier and BER of 10^{-6} post coding.

9. Scalability

1. Variable length packet modem is optimized for burst data traffic.
2. With appropriate support from the MAC, like bandwidth allocation and scheduling, the proposed PHY can carry various data types (IP, ATM, MPEG).
3. Fast packet acquisition minimizes modem overhead and enhances efficiency for short packets like ATM cells or MPEG frames
4. The proposed PHY will enable the use of long frames in order to avoid fragmentation of long packets like those used for carrying IP.