Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	Doc 802.16.3p-00/37 Outline of PHY Proposal for MMDS Communications
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Re:	Proposal submitted in response to Call for proposal on PHY specifications in IEEE 802.16.3 on 2000-9-15
Abstract	This document presents the outline of the PHY specifications for the Enhanced OFDM (EOFDM) and enhanced QAM (EQAM). The proposed PHY supports OFDM and QAM modulation with adaptive modulation and FEC on upstream and EOFDM with adaptive modulation on the down stream.
Purpose	Proposal for consideration as the PHY layer specifications for 802.16.3. Reference: 802.16.3c-00/37

Patent Policy and Procedures	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/notices>.

Proposal of PHY Layer for Broadband Wireless Access

IEEE 802 Plenary Session

Tampa, Nov 7, 2000

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Contributors

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Summary of Proposal

- OFDM is chosen for the downstream transmission
- Both OFDM and Enhanced QAM (EQAM) is supported on the upstream transmission
- Adaptive Modulation is applied to both upstream and downstream for OFDAM and EQAM
- Adaptive concatenated code
- MIMO (Antenna Diversity) is supported

PHY Characteristics

- PHY for LOS and NLOS conditions
- PHY optimized for maximum capacity and robustness
- Integrated PHY for
  - Single Carrier
    - Adaptive modulation
    - Adaptive FEC
    - Concatenated coding
    - Training signal
  - Multi Carrier
    - Adaptive modulation
    - Adaptive FEC
    - Concatenated coding
    - MIMO
- FEC based on common building blocks
- PHY transparent to MAC
- Up/down stream commonality

Equalization

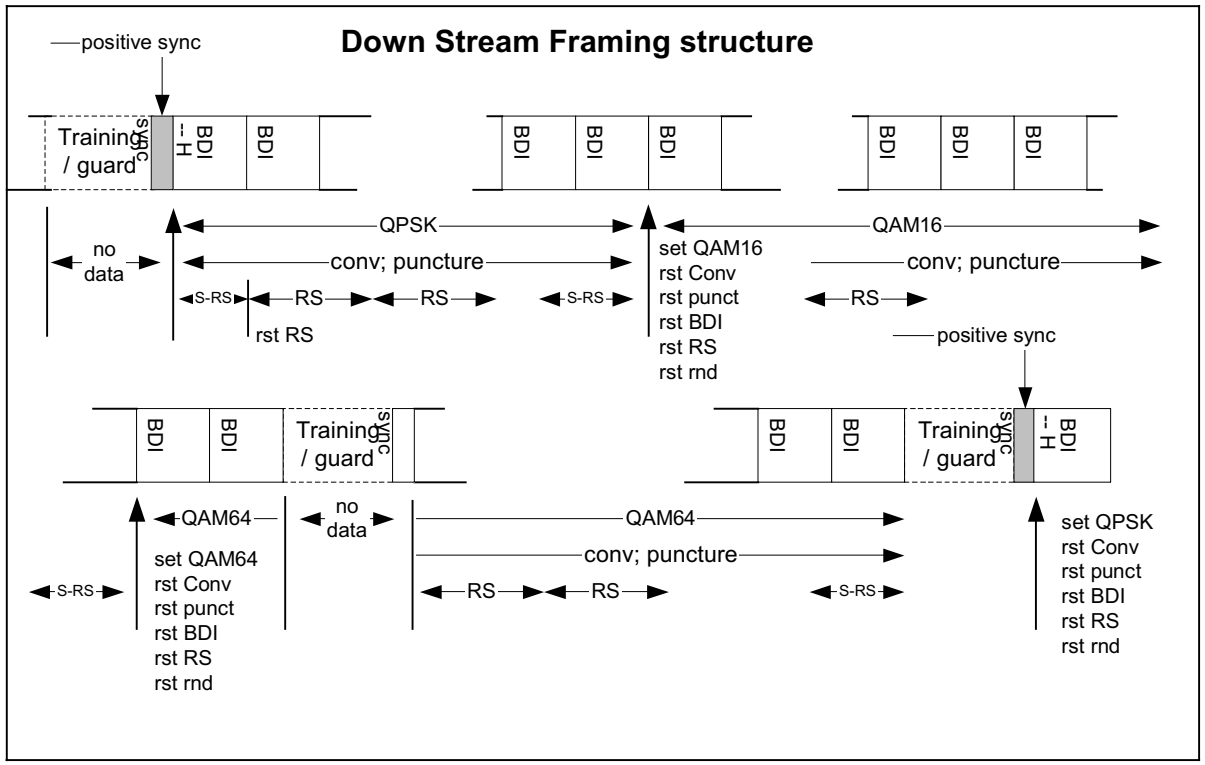
➢ Single Carrier

- Data aided LMS – for K > 2
- Training signal – for K > 0
- Training signal overhead < 2%

➢ OFDM

- K < 0
- Guard interval
- Pilot aided
- Guard & pilots overhead < 25%
- MIMO – optional

Data Framing for Downstream Transmission

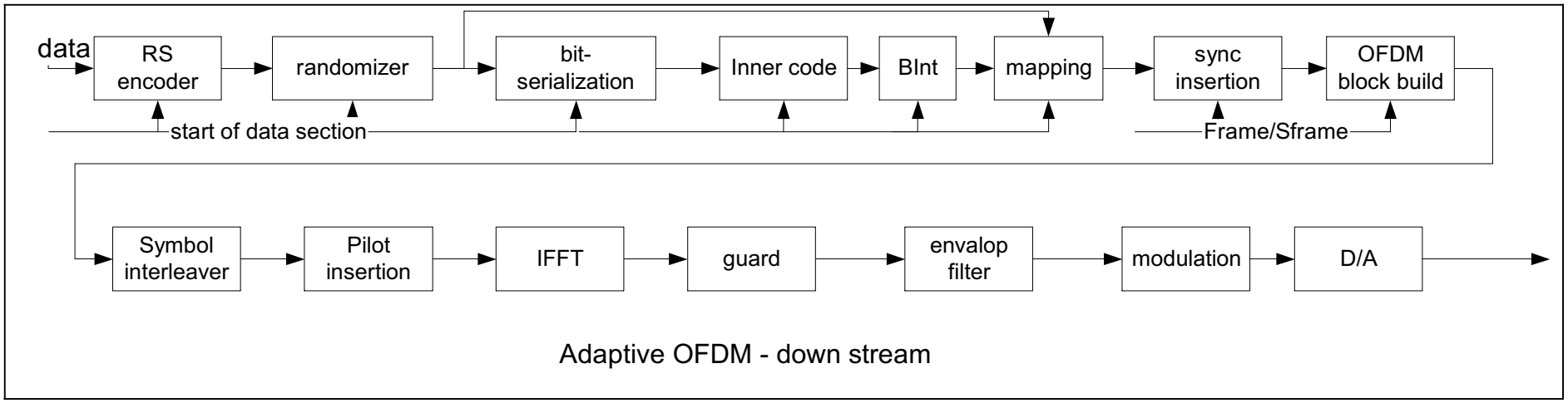


- OFDM 256→2K
- 1/3 (1/6 every 2nd symbol) evenly dispersed pilots
- Guard interval: 1/4, 1/8, 1/16
- Continuous OFDM symbol stream
- Symbol interleaving
- Data segments with different modulation
- Header signal (for PHY adaptive modulation) – QPSK

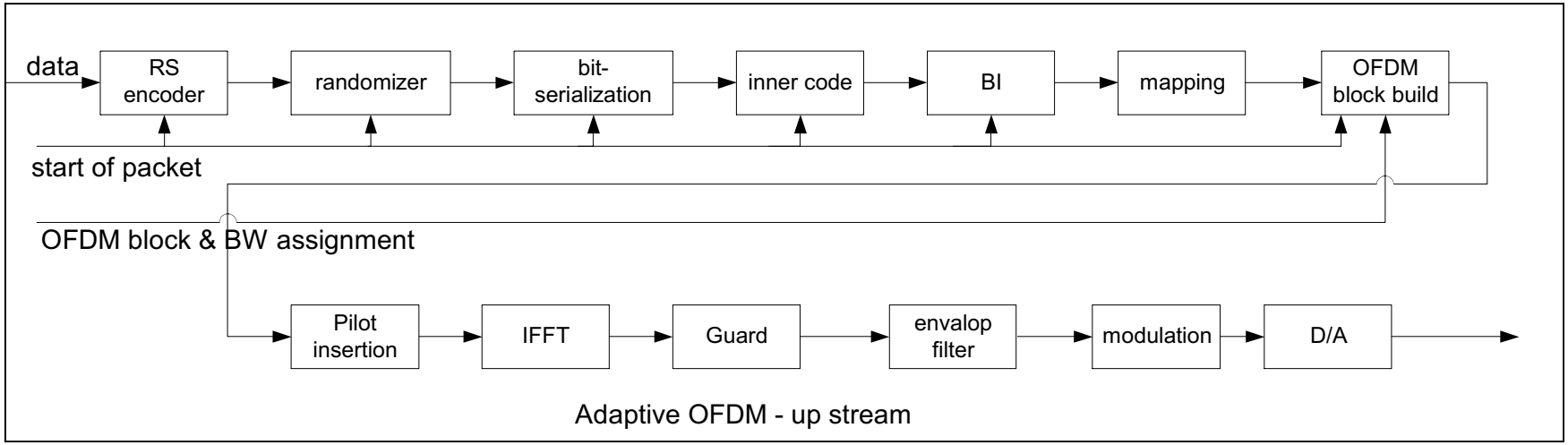
Forward Error Correction

- Concatenated coding
  - RS encoding
  - Randomizer
  - Convolutional encoding
  - Bit interleaving
- Adaptive FEC
  - Dynamic modulation level
  - Dynamic code strength – puncture rate
- RS encoding
  - G(x) = x^8 + x^4 + x^3 + x^2 +1
  - Programmable N,T
  - RS + shortened code
  - Randomizer
  - 1 + X^14 + X^15
- Convolutional encoding
  - G1 = 171 ; G2 = 133, K=7
  - Puncture: 1/2, 2/3, 3/4, 5/6, 7/8
  - Burst termination
- Bit interleaving
  - Programmable block interleavi
- Mapping
  - Gray coding
  - QAM4–16–64

Block Diagram for Downstream OFDM with Adaptive Modulation



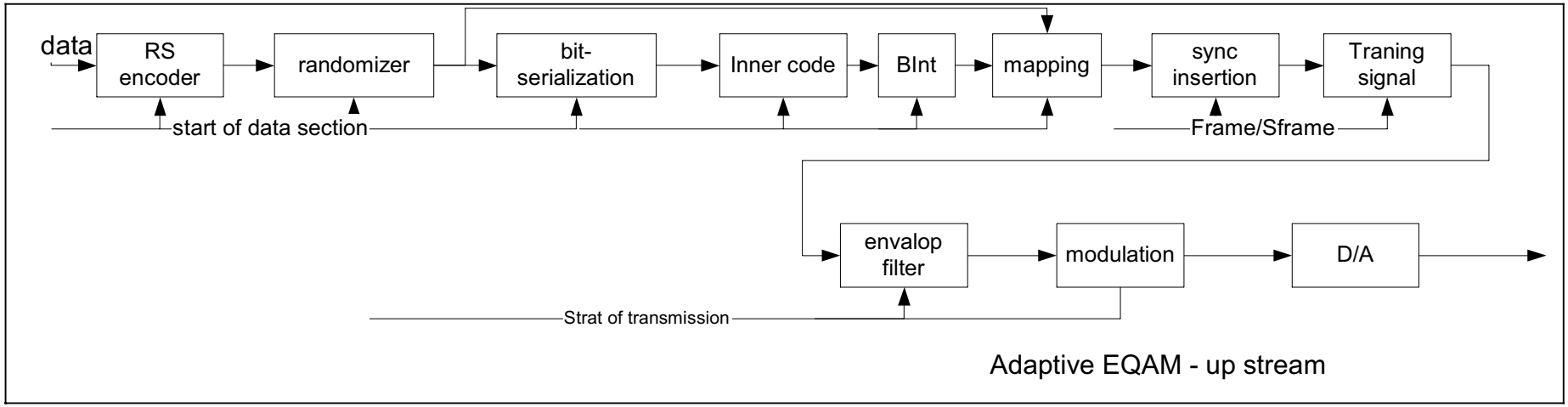
Block Diagram for Upstream OFDM with Adaptive Modulation



Upstream Multi Carrier

- Framed transmission
- FDMA combined with TDMA
- Adaptive modulation
- Adaptive FEC

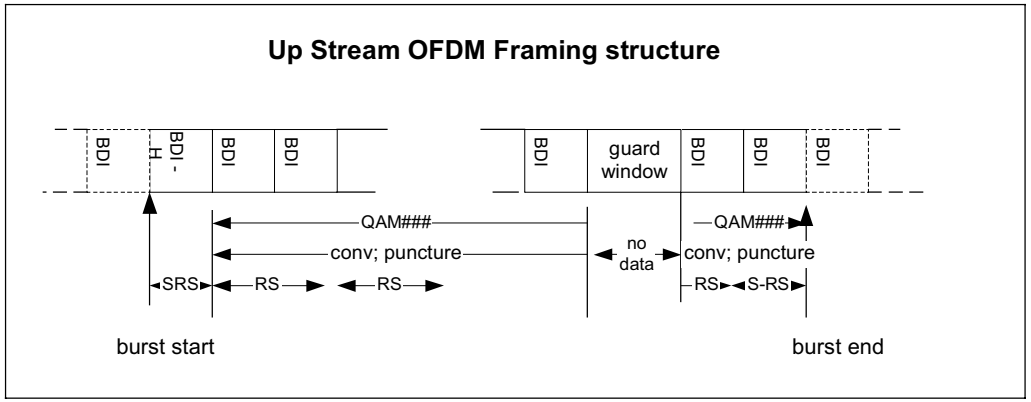
Block Diagram for Upstream EQAM with Adaptive Modulation

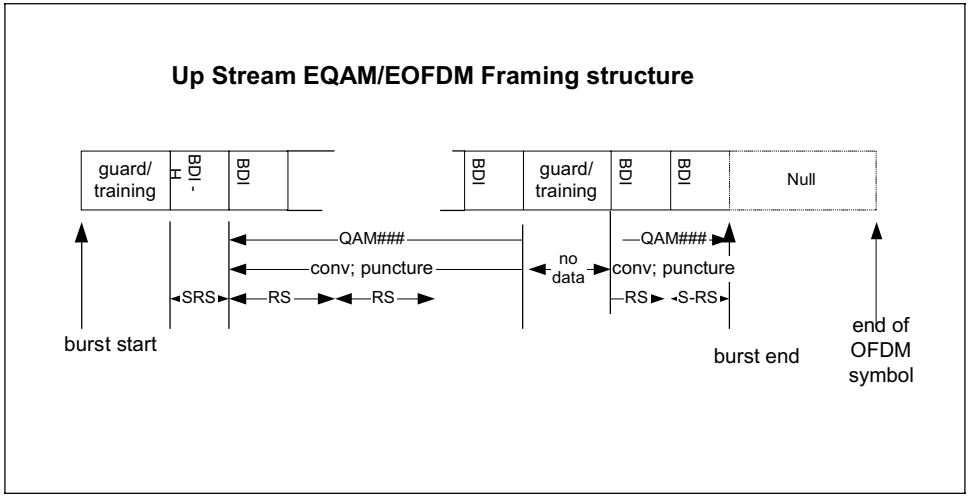


Upstream Single Carrier

- Dynamic length of bursts
- Second path equalization
- Adaptive modulation
- Adaptive FEC

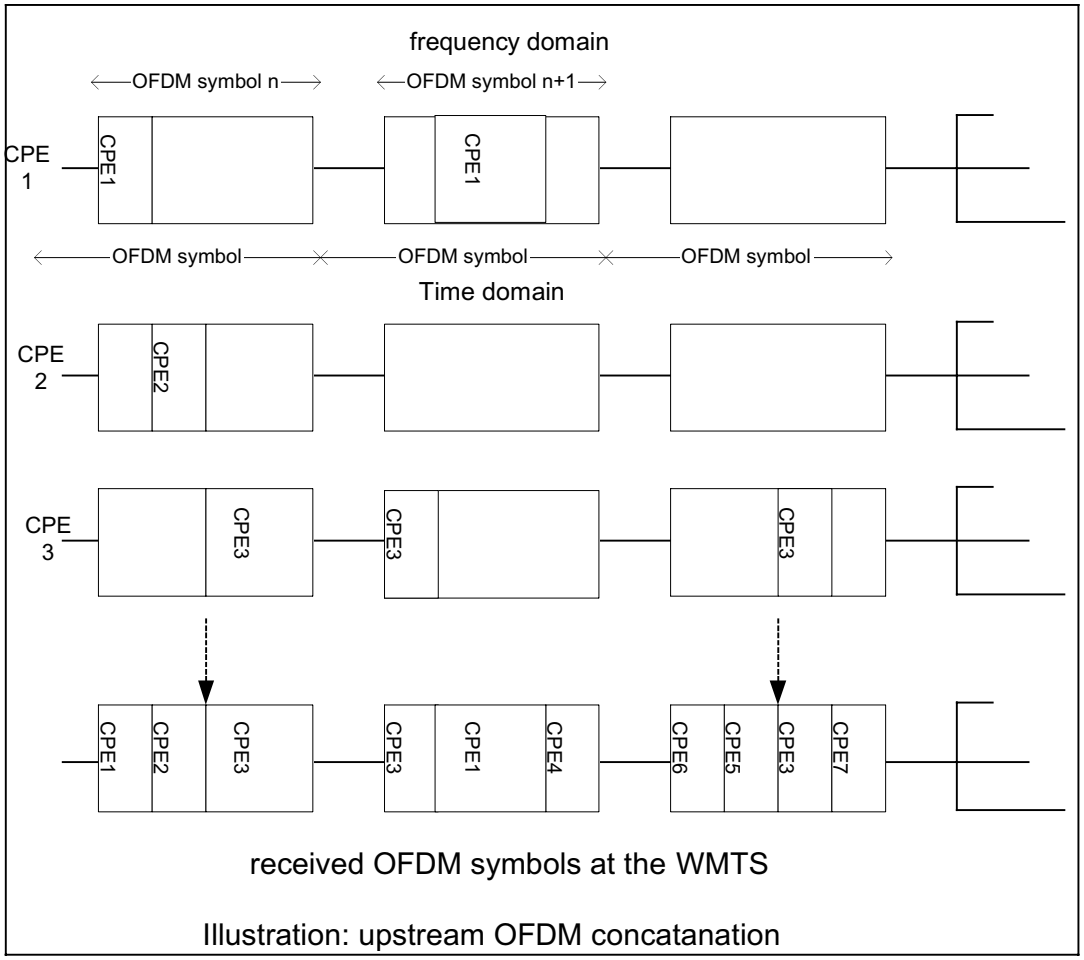
Data Framing for Upstream Transmission





- **Single Carrier**
  - **Preamble (training) – QPSK**
  - **Data – QAM4–16–64**
  - **Burst of symbols stream**
- **Multi Carrier**
  - **OFDM**
  - **FDMA/TMDA combined operation**
  - **1/6 pilots**
  - **Guard interval: 1/4, 1/8, 1/16**
  - **Burst – concatenated OFDM symbol**

Up stream FDMA



Advantages of Proposed PHY

- Downstream OFDM transmission results in robust coverage in non-line of sight situations.
- Adaptive modulation on the downstream allows for higher data rates for users with good line of sight while maintaining robust service to users with non line of sight.
- Only one mode (OFDM) of downstream transmission ensures interoperability of base station with various CPE's.
- Choice of Single Carrier or Multicarrier upstream channels allows optimization of upstream throughput and robustness.
- Adaptive modulation on upstream (OFDM and QAM) results in optimized data rates depending on signal strength.

Enhanced QAM (EQAM)

- EQAM improves multipath reception of QAM signals
- A training signal is of fixed length and duty cycle is concatenated with the QAM signals
- The rate of training signal insertion can be set depending on the application
- Adaptive modulation is also applied

Adaptive Modulation

- Data-carrying sub-carriers within each OFDM signal can be modulated in QPSK, QAM 16 and QAM 64
- FEC also depends on signal strength
- Strongest signals get QAM 64, Moderate QAM 16 and the weakest getting QPSK modulated data