Proposal for IEEE 802.16m on Link Adaptation, Packet Structure, and HARQ

Document Number: IEEE C802.16m-08/614

Date Submitted: 2008-07-07

Source:

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Re: IEEE 802.16m-08/024 – Call for Contributions on Project 802.16m System Description Document (SDD), on the topics of "Link Adaptation" and "Hybrid ARQ"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Scope

- This contribution presents a proposal for packet formats and structures and HARQ methods for IEEE 802.16m
  - Packet formats and HARQ methods proposed to adapt the transmission to MS transmission resources and channel quality

IEEE 802.16m System Requirements

- The TGm SRD (IEEE 802.16m-07/002r4) specifies the following requirements:
  - Section 5.2 Complexity
    - IEEE 802.16m should minimize complexity of the architecture and protocols and avoid excessive system complexity. It should support low cost devices.
  - Section 6.1 Peak data rate
    - IEEE 802.16m shall support the peak rate on the DL:
      - Baseline (2x2): 8.0 bps/Hz
      - Target (4x4): 15.0 bps/Hz
  - Section 7.4 Cell coverage
    - IEEE 802.16m shall provide significantly improved coverage with respect to the WirelessMAN OFDMA Reference system.
- The proposed link adaptation, packet structure, and HARQ schemes target the above requirements.

Introduction

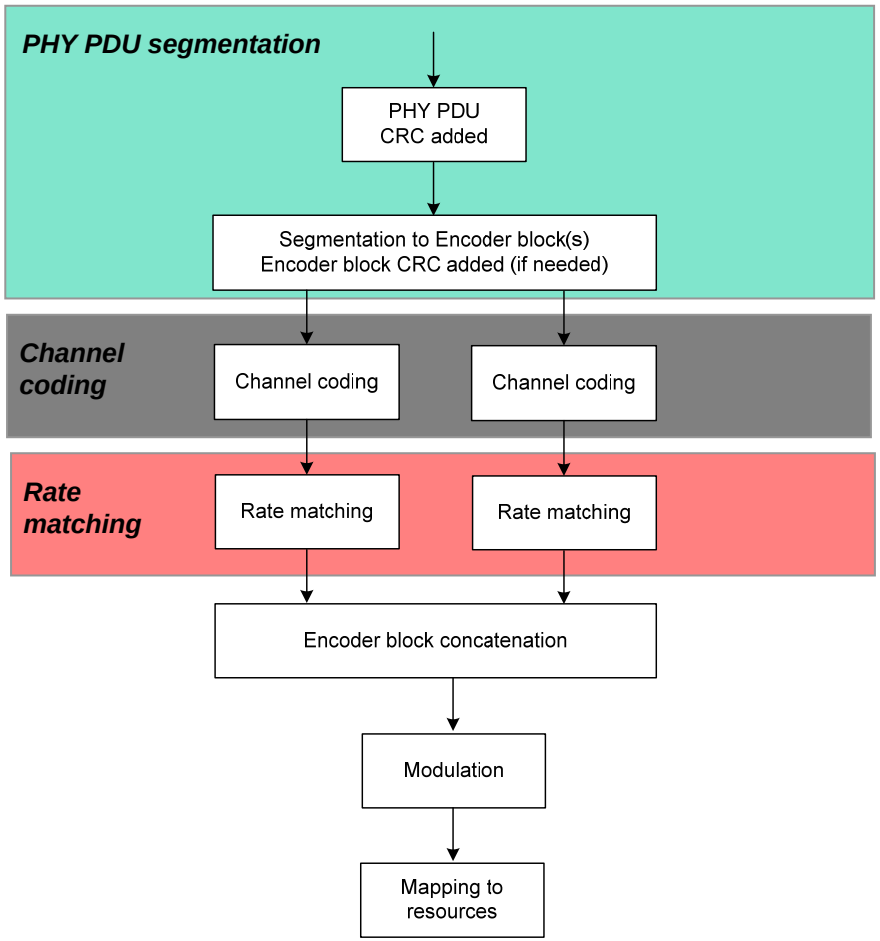
- Link adaptation is achieved through proper MCS selection, and PHY packet formation. This can include:
  - Encoder block formation
    - PHY packet segmentation
    - Channel coding
- HARQ Methods
  - Rate matching
  - MIMO-HARQ
  - MCW MIMO
- The proposed procedure is outlined in the following slides

Procedure to Determine Modulation Level and PHY PDU Size

- Procedure:
  - BTS determines MCS and resource allocation for MS
    - MCS can be determined from CQI feedback from MS
  - MCS levels are defined by
    - Modulation level
    - Approximate coding rate of first transmission
  - MCS has 16-32 levels (4-5 bits)
- Example table shown
  - MCS levels 14-16 cannot be completely received from a single transmission
- MCS and resource allocation define PHY PDU size

MCS	Modulation (1st)	Code rate (1st Tx)	Spectral Efficiency
0	QPSK	1/3; rep 4	0.1666
1	QPSK	1/3; rep 2	0.33
2	QPSK	1/3	0.66
3	QPSK	½	1.0
4	QPSK	2/3	1.33
5	QPSK	3/4	1.5
6	QPSK	4/5	1.8
7	16 QAM	1/3	1.333
8	16QAM	1/2	2.0
9	16QAM	2/3	2.66
10	64 QAM	1/3	2.0
11	64 QAM	1/2	3.0
12	64 QAM	2/3	4.0
13	64 QAM	5/6	5.0
14	64 QAM	1/2	6.0
15	64 QAM	2/3	8.0
16	64 QAM	5/6	10.0

PHY Procedure



- PHY PDU passed to PHY layer according to size of resources available and transmission MCS
  - CRC_{PHY} is 16 to 24 bits for reliable performance
- PHY PDU can be segmented into encoder blocks (EB) to limit encoder block size
  - CRC_{EB} added to facilitate early termination to decoding
  - CRC_{EB} is smaller than CRC_{PHY}
- The PHY PDU can also be broken into two smaller PHY PDU, and allocated separately
  - BS implementation dependent
- Both PHY PDU size and encoder block segmentation sizes are flexible

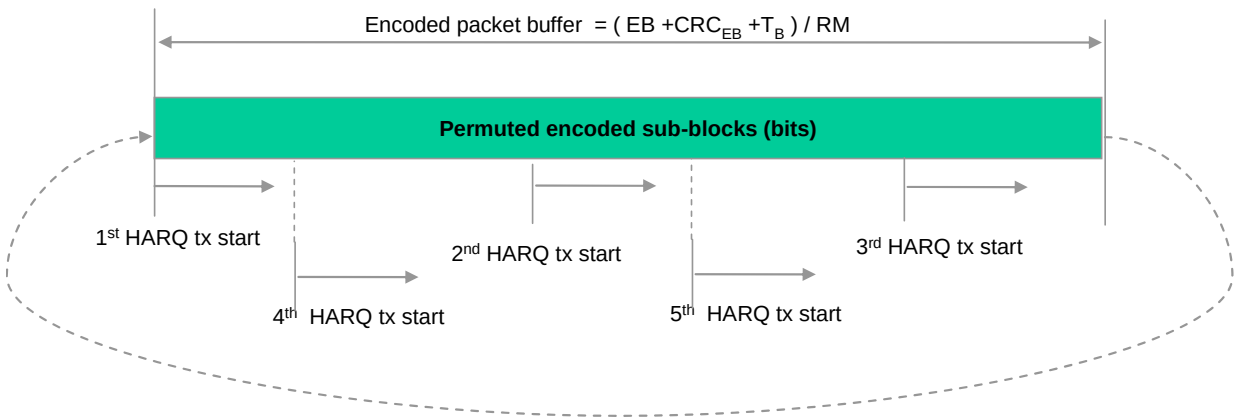
PHY PDU Segmentation

- PHY PDU can be segmented into encoder blocks (EB) to limit encoder block size
  - Segmentation prevents encoder blocks greater than Max_Encoder_Block_Size
  - Max_Encoder_Block_Size capability can be different for different MS
  - Unique relationship between PDU and EB sizes. EB sizes are derivable by MS from MCS and number of resources
- Encoder block CRC is added to each block when there is more than one encoder block.
- Encoder block sizes are not limited to a small set, but are variable depending on segmentation of PHY PDU
  - Mother rate 1/3
  - Flexible interleaver tables are used to accommodate various packet sizes

Link Adaptation with HARQ

Rate Matching for HARQ

- First HARQ transmission will be of same code rate as indicated MCS
  - The encoder block /PHY PDU size is defined exactly from MCS and resource allocation, so code rate of packet is as indicated by MCS
- Subsequent HARQ transmissions may have slightly different resource allocation sizes. In this case, parity bits maybe removed or added to the transmission to fit the different resource allocation size.
  - Each HARQ transmission has a particular start point along the encoded packet buffer.
  - Each re-transmission can be adapted to the size of the re-transmission resource allocation size by using as many bits as necessary.
  - Once the end of the buffer is reached, encoded bits are taken from the beginning of the encoded packet buffer
    - Chase combining is simply a specific case of this method
  - The encoded bits are mapped to resources in different order, using a predefined interleaving pattern for each HARQ transmission.



Considerations for HARQ and MIMO (1/2)

- We also consider two link adaptation enhancements to MIMO-HARQ schemes using HARQ:

1. STBC-HARQ

– In STBC-HARQ, a first HARQ open-loop (OL) transmission is sent using spatial multiplexing (SM).
– In a second re-transmission, the re-transmitted symbols are arranged such that they form STBC code with the pair of original symbols.
– This can give a performance improvement over conventional re-transmissions

Considerations for HARQ and MIMO (2/2)

2. Symbol Swapping

– For a closed loop precoding scheme, symbols from the same codeword are sent on separate MIMO layers.
– For a HARQ transmission, the symbols can be swapped by layers and therefore benefit the weaker eigen channel of the first transmission.
– The swapping during HARQ re-transmission results in more balanced channels for both streams for close-loop precoding.

Consideration for HARQ MCW MIMO

- A unique scenario exists for multi-code word (MCW) MIMO transmissions, as multiple PHY PDU streams can be sent in parallel
  - In this case, each codeword transmission is acknowledged (ACK/NAK) separately

- For MCW with HARQ retransmissions:
  - OL MIMO case:
    - When one of the codewords finishes HARQ transmissions, the rank of the transmission is reduced accordingly.
    - The MS determines that the rank will be reduced after ACK of a packet
  - CL MIMO case:
    - When one of the codewords finishes HARQ transmissions, the rank of the transmission is reduced accordingly.
      - Using the same transmission rank, but sending the remaining codewords on all precoding layers is FFS.

Summary

- A MCS table based on spectral efficiencies is proposed for IEEE 802.16m systems
- The link adaptation structure proposed also for maximum encoder block sizes to limit MS complexity
- A rate matching scheme for HARQ is proposed
- MIMO-HARQ methods suggested (STBC-MIMO and Symbol Swapping) to improve performance

Proposed SDD Text

11.x.1. Physical Packet Structure

11.x.1.1 PHY PDU Segmentation

[Insert content from slide 5 and 6]

11.x.1.1.1 Coding and Modulation

[Insert content from slide 7]

11.x.1.1.2 HARQ Transmission Techniques

11.x.1.1.2.1 Rate matching

[Insert content from slide 9]

11.x.1.1.2.2 MIMO-HARQ

[Insert content from slide 10 and 11]

11.x.1.1.2.3. MCW MIMO

[Insert content from slide 12]