Slides for Joint PRU Coding and Independent PRU Modulation for Link Adaptation

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Purpose:
Consideration by the IEEE 802.16m TG for SDD contents

Problem Statement (1)

- Binary-valued data block of length κ is input to an FEC encoder parametrized by the pair (η, κ) where η denotes the length of an encoded data block.

- Encoded data block is bit-interleaved and input to an M-QAM modulator. Parameter M may be set to $M = 4$ (QPSK), $M = 16$ (16-QAM) or $M = 64$ (64-QAM). The M-QAM modulator outputs a modulation symbol vector of length $\beta = \eta/m$ where $m = \log_2(M)$.

- The length β of a modulation symbol vector is dependent on the triple (η, κ, m). In legacy 802.16 systems κ, η and m are specified so that β is always a divisor of two. It is assumed that this is also true for 802.16m systems.

- For example, if $\kappa = 320$, $\eta = 640$, and $m = 2$ the length of the resulting modulation symbol vector is $\beta = \eta/m = 320$.

Problem Statement (2)

- Table 1 shows an example set of values for κ, η, m and β.

Code Rate κ/η	Data Block Size κ in Bits	Encoded Data Block Size η in Bits	Number of Bits m per M-QAM Symbol	Number of M-QAM Symbols β per M-QAM Symbol Vector
1/2	320	640	2	320
2/3	640	960	4	240
3/4	960	1280	4	320
5/6	1280	1536	6	256

- Physical Resource Units (PRUs) dimensions are defined as $P_{sc} = 16$ and $N_{sym} = 6$ where P_{sc} is in units of OFDMA subcarriers and N_{sym} in units of OFDMA symbols. A user's PRUs may be located anywhere within a subframe's time-frequency plane.

- The area of a PRU is $P_{sc} \times N_{sym} = 108$. This area also equals the maximum length β of a modulation symbol vector that can be supported by a PRU.

- The mismatch between β and the fixed product $P_{sc} \times N_{sym}$ complicates coding, modulation and link adaptation.

Two Candidate Approaches for PRU-based Link Adaptation

- **Approach 1 - Independent PRU Coding and Independent PRU Modulation**:
  - Both the coding and modulation of each of a user's allocated PRUs is adapted to each of the PRU's channel conditions.
  - Based on a user's channel conditions each PRU is encoded and modulated separately.
- **Approach 2 - Joint PRU Coding and Independent PRU Modulation**:
  - The modulation of each of a user's allocated PRUs is adapted to each of the PRU's channel conditions.
  - Encoding is applied over all of a user's PRUs. The coding of a user's allocated PRUs is matched to the aggregate channel conditions of all of its allocated PRUs.
  - Each user codeword is segmented, the segments are then individually modulated. The modulated segments are then mapped to all of the user's allocated PRUs that may dispersed in time, frequency and space.
  - Code adaptation may be based on a effective metric (e.g. Mutual Information Based Effective SNR [1, 3, 6]) derived from the channel conditions associated with all of a users's allocated PRUs.
  - Hence, based on a user's channel conditions each of the user's PRUs is modulated separately but the PRUs transmit segments of the same user codeword.

Some Characteristics of Approach 1(Independent PRU Coding and Independent PRU Modulation)

- Advantages:
  - Finer granularity PRU-based link adaptation is possible.

- Disadvantages:

  - Coding gain is limited by PRU size. A single PRU may not support a long codeword. An increased error rate may result if a PRU's SINR is low and its size is small.

  - The number of data bits supported per fixed-sized PRU and the number of data bits per encoded source data block may be difficult to match, hence a throughput reduction due to encoder pad bits.

  - Interleaver length is limited by PRU size.

  - Multiple PRU encodings are required when a user is allocated multiple PRUs, hence a potential for an increase in implementation complexity and power consumption.

  - HARQ must support multiple codewords when a user is allocated multiple PRUs with different encodings. Hence the potential for an increase in overhead and signaling.

Some Characteristics of Approach 2 (Joint PRU Coding and Independent PRU Modulation)

- Advantages:
  - Coding gain is not limited by PRU size. The mapping of an information source's data block to a user's PRUs is decoupled from the length of the data block. Data blocks may be encoded using long DBTC or LDPC codewords that are mapped to multiple PRUs, codeword segments may be dispersed in time, frequency and space over multiple user PRUs. Small data blocks may be encoded and mapped to a single PRU.
  - Interleaver length is not limited by PRU size. Interleaving is performed over the number of PRUs allocated to a user, hence interleaver length is increased when the number of allocated PRUs is greater than one.
  - HARQ must support only one codeword when a user's data block is allocated multiple PRUs. Hence the potential for a decrease in overhead and signaling.
  - Potential reduction in overhead since coding is specified for all of a user's PRUs rather than each of its PRUs.
  - Potential reduction in implementation complexity and power consumption since a single encoding operation is required for all of a user's allocated PRUs.
- Disadvantages
  - Coarser granularity in PRU link adaptation since PRU adaptation is based on a metric derived from the channel conditions associated with all of a users's allocated PRUs

Propose Approach 2: Joint PRU Coding and Independent PRU Modulation for Link Adaptation

- Approach 2 has benefits for 802.16m systems
- Propose that joint PRU coding and independent PRU modulation be used for 802.16m systems.
- In this approach PRU size can be decoupled from the information source models as defined in EMD.
- PRU sizes do not need to match data block sizes produced from information source model, they are matched to physical channel characteristics.
- In the engineering literature [1, 3, 4, 5] it is shown by simulation that this approach performs excellently.

Proposed Text

Link Adaptation - Baseband Coding and Modulation

Baseband link adaptation will employ joint Physical Resource Unit (PRU) coding and independent PRU modulation. In this approach the modulation of each of a user's allocated PRUs is adapted to the PRU's channel conditions. The coding of a user's allocated PRUs is adapted to the channel conditions of all of its allocated PRUs. Each user codeword is segmented, the segments are then mapped to all of the user's allocated PRUs. Modulation adaptation is based on SINR measurements for each PRU. Code adaptation is based on an effective SINR metric (e.g. Mutual Information Based Effective SNR) derived from the channel conditions associated with all of a users's allocated PRUs. Hence, based on a user's channel conditions each of user's PRUs is modulated separately but the PRUs transmit segments of the same user codeword.

References

See latest revision of IEEE C802.16m-08/696 for details

1. Stiglmayr, Bossert, and Costa, "Adaptive coding and modulation in OFDM systems using BICM and rate-compatible punctured codes," European Wireless, Paris, Apr. 2007.
2. Plass, Dammann, and Svensson, "Block-Equidistant resource mapping in OFDMA, MC-CDMA, and SS-MC-MA," In Proceedings 12th International OFDM Workshop, Hamburg, Germany, Aug. 2007.
3. Pfletschinger, Piatyszek, and Stiglmayr, "Frequency-Selective Link Adaptation using Duo-Binary Turbo Codes in OFDM Systems," Mobile and Wireless Communications Summit, 2007. 16th IST, Volume , Issue , 1-5 July 2007 Page(s): 1 - 5
4. Sternad, T. Svensson, Ottosson, Ahlen, A. Svensson, and Brunstrom, "Towards Systems Beyond 3G Based on Adaptive OFDMA Transmission," Proceedings of the IEEE, Volume 95, Issue 12, Dec. 2007 Page(s): 2432 - 2455.
5. Svensson, Falahati, and Sternad, "Coding and Resource Scheduling in Packet Oriented Adaptive TDMA/OFDMA Systems," Vehicular Technology Conference, 2006. VTC 2006-Spring. IEEE 63rd, 7-10 May 2006, Page(s): 1600-1604
6. Brueninghaus, Astely, Salzer, Alexiou, Karger, and Seraji, "Link performance models for system level simulations of broadband radio access systems," in PIMRC, 2005...
7. IEEE C802.16m-08/003r3, Draft IEEE 802.16m SDD.