Adaptive Frequency Interleaving for HARQ

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>
Venue:
Re: IEEE 802.16m-08/016r1 “Call for Contributions on Project 802.16m System Description Document (SDD)”
(Target topic: Hybrid ARQ)
Base Contribution:
C80216m-08_477
Purpose:
For discussion and approval by TGm

Introduction

- HARQ are packet retransmission mechanisms that facilitate efficient combining of received information from multiple transmissions
- There are two types of HARQ schemes:
  - Incremental Redundancy (IR) → additional coded bits are transmitted;
  - Chase Combining (CC)→ same coded bits are retransmitted
- This contribution introduces an enhanced HARQ-CC scheme that exploits frequency diversity via *adaptive interleaving*

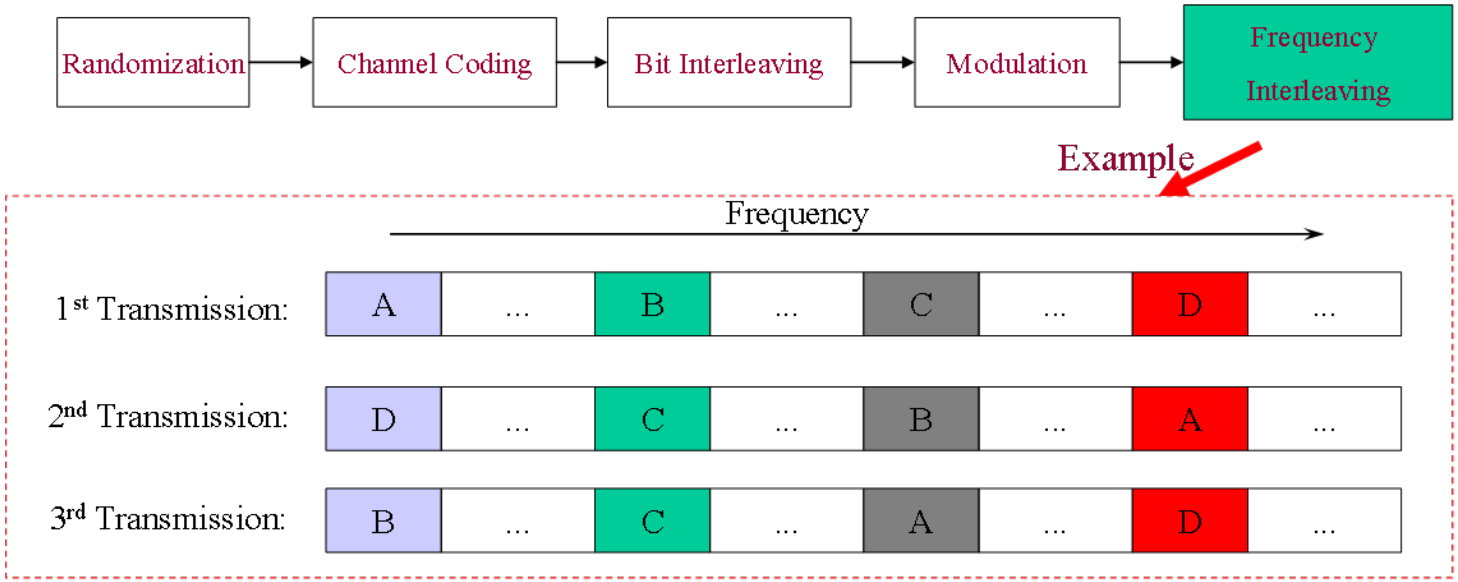
Motivation

- In conventional HARQ-CC
  - When the transmitter receives a NAK, it retransmits the packet in the same *fixed* format. However, the symbols in the previous transmission(s) that experience deep fade may once again suffer from deep fade. As such, retransmission may not provide sufficient SNR gain to the *bad* symbols, and these symbols become the bottleneck in decoding
  - ACK/NACK feedback carriers only 1 bit and there is no means to provide the transmitter with the knowledge of the information the receiver needs the most in the next retransmission
- Adaptive frequency interleaving
  - There are significant overheads associated with the delivery of 1 bit ACK/NAK. It is more efficient if more bits are contained in the ACK/NAK feedback, i.e., to perform soft HARQ feedback.
  - Proposed scheme:

    The receiver has (partial) channel knowledge. We propose adaptive frequency interleaving whereby 1) the receiver chooses the ordering of the symbols in the packet during the next retransmission to enhance decoding performance, and 2) the receiver communicates the chosen *symbol ordering* or *interleaving pattern* to the transmitter via soft NAK

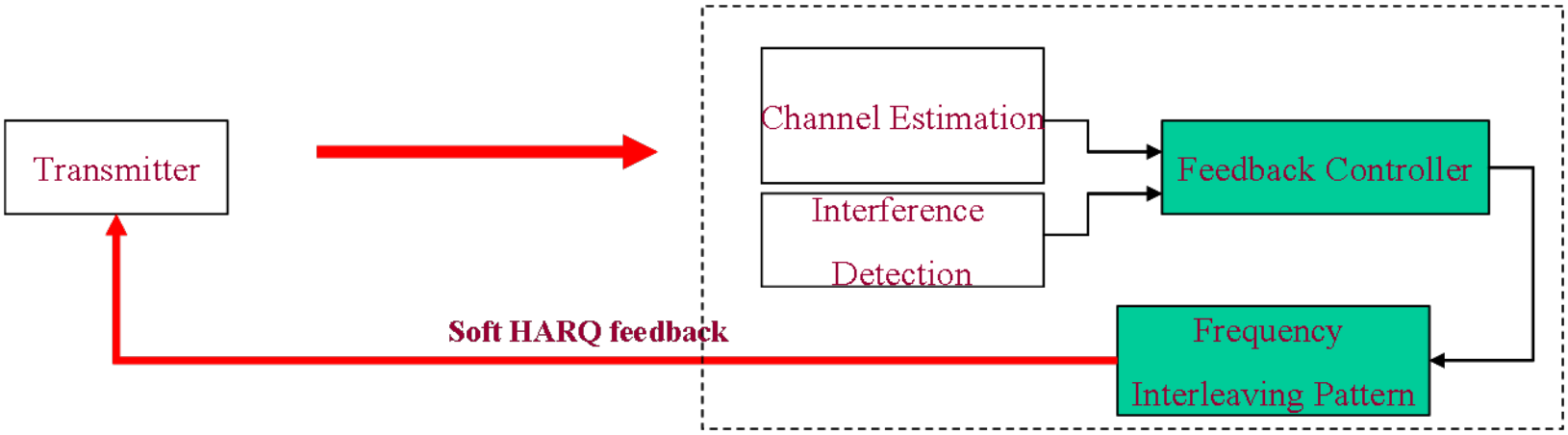
Proposed Scheme: Frequency Interleaving

- A common set of interleaving patterns is known to both the transmitter and the receiver
- Each interleaving pattern defines a unique mapping between the modulated symbols and the frequency subcarriers
- Depending on the channel realization, the interleaving patterns may yield different decoding performances

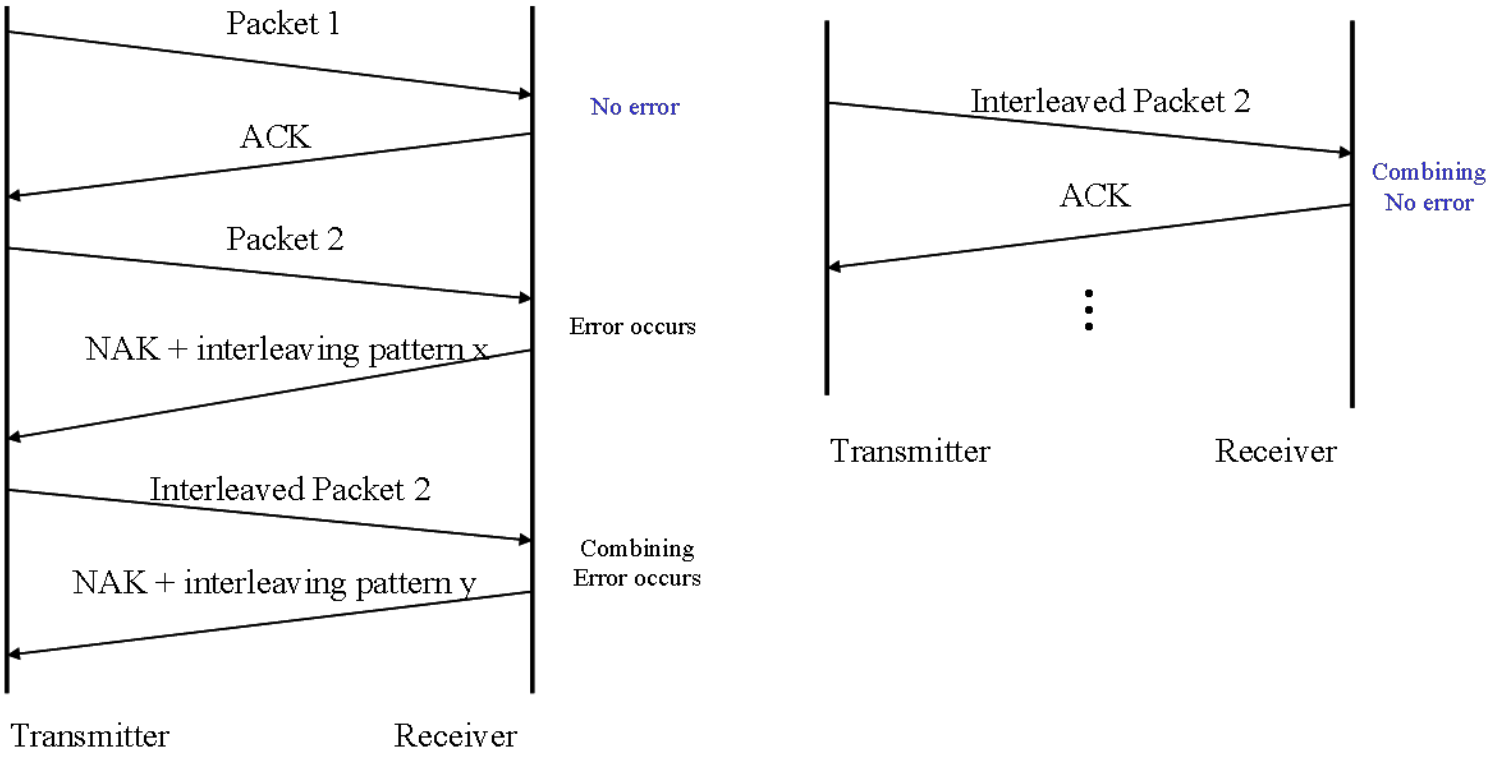


Proposed Scheme: Adaptive Interleaving

- The receiver uses estimated channel state information to choose the most suitable interleaving pattern and feedback the index of the pattern to the transmitter
- The transmitter applies the interleaving pattern indicated in the NAK feedback in the subsequent retransmission



Proposed Scheme: Message Flow



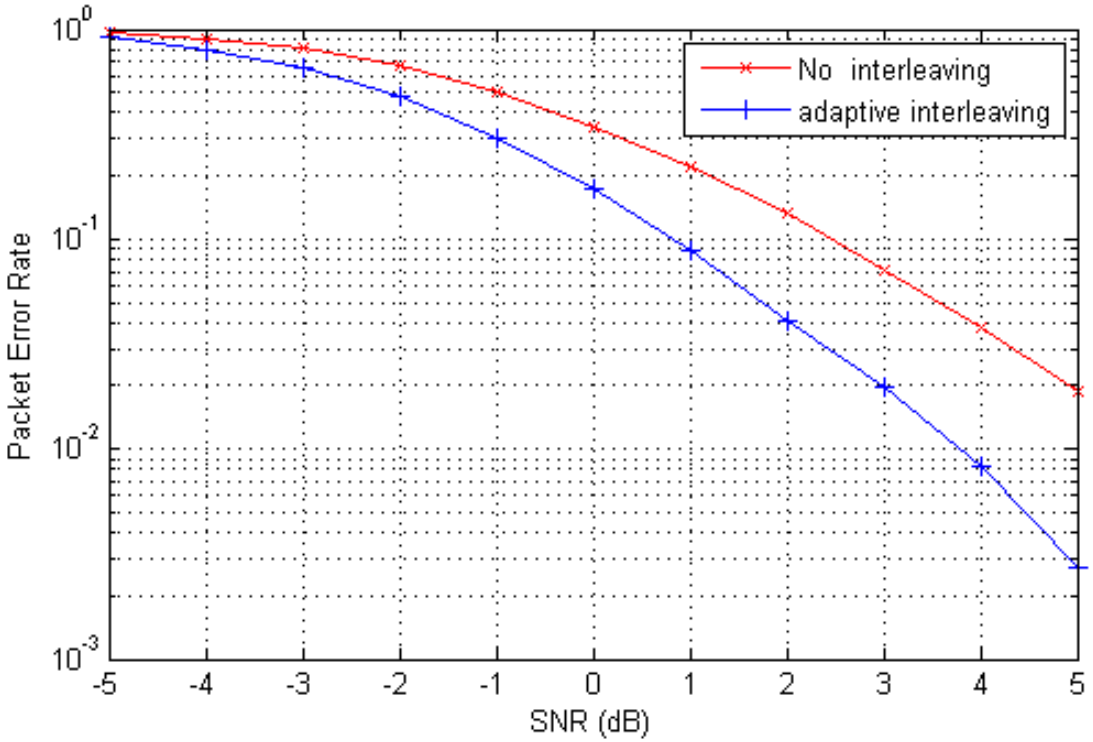
Pattern Selection Algorithm

- Pattern selection to maximize mutual information
- Let $\{h_{i,1}, h_{i,2}, ..., h_{i,n-1}\}$ be the channel gains affecting the i^{th} transmitted symbol in the first n-1 transmissions
- Let h_i^m be the channel gain corresponding to the i^{th} transmitted symbol when the m^{th} interleaving pattern is used
- Suppose there are K transmitted symbols
- In the n^{th} transmission, the controller chooses an interleaving pattern that maximizes the summation of the mutual information of each symbol, i.e.

$$\max_{m=1}^{M} \prod_{i=1}^{K} \left(1 + \frac{|h_i^m|^2 + \sum_{j=1}^{n-1} |h_{i,j}|^2}{\sigma_z^2} p\right)$$

where p is the transmission power and σ_z^2 is the noise power.

Simulation Results



The proposed HARQ scheme adaptive frequency interleaving achieves about **1.3dB gain** over conventional HARQ scheme without frequency interleaving

- Simulation parameters:

  Channel: ITU PB, 3km/hr

  FFT Size: 1024

  Maximum number of retransmissions: 4

  Channel Coding: Rate ½ Convolutional Code

  Number of information bits per coding block: 48

  Modulation: QPSK

  Interleaving patterns: 8

Conclusion

- In the contribution, we introduce a low complexity adaptive frequency interleaving scheme that can effectively improve HARQ performance of 802.16m systems

Text Proposal to SDD

----------Start text proposal----------

[*Adopt the following text in the ToC of P802.16m System Description Document (SDD)*]

11. x.x.x HARQ

Retransmitted symbols are interleaved and the interleaving pattern is adapted by the feedback from the receiver.

----------End text proposal----------

Backup Slides

System Flowcharts