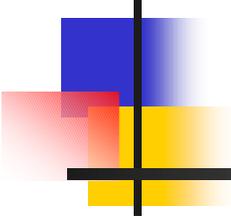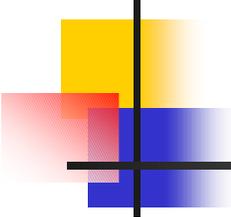# Coding Proposal for EFM-Cu

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Channel Coding in ADSL and VDSL

- ADSL recommendation G.992.1 (G.dmt) specifies concatenated Reed-Solomon (RS) and trellis-coded modulation (TCM)
  - Byte-oriented RS code [in GF(256)] is mandatory
  - 16-state, 4D trellis-code is optional

- G.992.2 (G.lite) specifies RS coding only (no TCM)

- TCM will be mandated in G.dmt.bis and G.lite.bis recommendations for upstream and downstream transmission and reception (independently enabled during initialization) [1]

- VDSL specifications (both multicarrier and single carrier PHYs) include RS coding only [2]
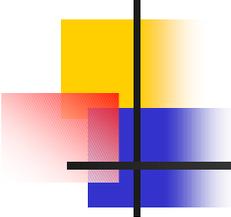
Net Coding Gains for RS Codes

- RS codeword length and number of redundancy bytes selected to maximize performance

- For DSL transmission, GF(256) RS coding achieves net coding gains of up to ~3.5 dB (e.g., [3]) for bit-error rate of 10^{-7}, with typical net coding gain values in the range of 2 to 3 dB (e.g., [4], [5])

- Therefore, RS-only coding falls short of providing coding gain values that are needed if we want to operate the EFM link close to its capacity and thereby maximize reach and rate
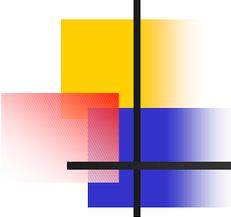
Concatenated Coding Structure

- The motivation for concatenating two coding schemes is to achieve large coding gains with affordable decoding complexity

- Concatenated outer RS & inner TCM is well suited for DSL transmission
  - Outer RS code provides coding gain and mitigates effects of impulse noise (in conjunction with interleaving)
  - Inner TCM extends the achievable coding gain

- With concatenation, the respective coding gains of RS and TCM do not add up, but total coding gain is greater than either alone (up to ~ 5.5 dB [4])
  - TCM alone achieves a coding gain of up to ~ 4dB
  - Trellis decoding of TCM is subject to error bursts that can be corrected by the outer interleaved RS code
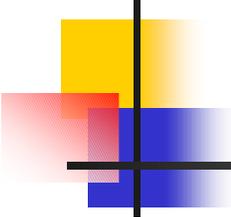
Proposed Coding Structure for EFM

- We recommend to adopt a *concatenated coding* structure for EFM

  - ➢ Outer RS (mandatory) for coding gain as well as impulse noise robustness

  - ➢ Inner TCM (optional) for performance improvement

- Concatenated RS+TCM essential to operate the EFM link close to channel capacity and to maximize reach and distance

  - ➢ Overall coding gain could be increased in the future by replacing the inner trellis-code with a more powerful coding scheme
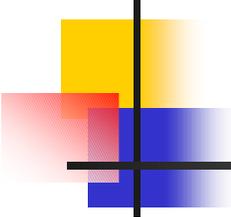
References

1. "Draft Recommendation G.dmt.bis," Issues List, ITU-T Study Group 15/4, Document U17R3, Geneva, Oct. 2001.

2. "VDSL Technical Specification Part 2," T1E1.4/2001-011R1, and "VDSL Technical Specification Part 3," T1E1.4/2001-013, Nov. 2001.

3. "Performance reference for the trellis and Reed-Solomon codes," Nortel Networks, ITU Contribution CF-073, Clearwater, FL, 8-12 Jan. 2001.

4. T. Starr, J. Cioffi, and P. Silvermann, "Digital Subscriber Line Technology," Prentice Hall, 1999.

5. L. Zhang and A. Yongacoglu, "Multilevel Reed-Solomon coding in Asymmetric Digital Subscriber Lines," in *Proc. ISCC 2000*, pp. 40-45.