100BASE-Cu
Dual Mode Proposal

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Baseline Proposal

ELASTIC NETWORKS

100 Mbps *Dual-Mode* Proposal

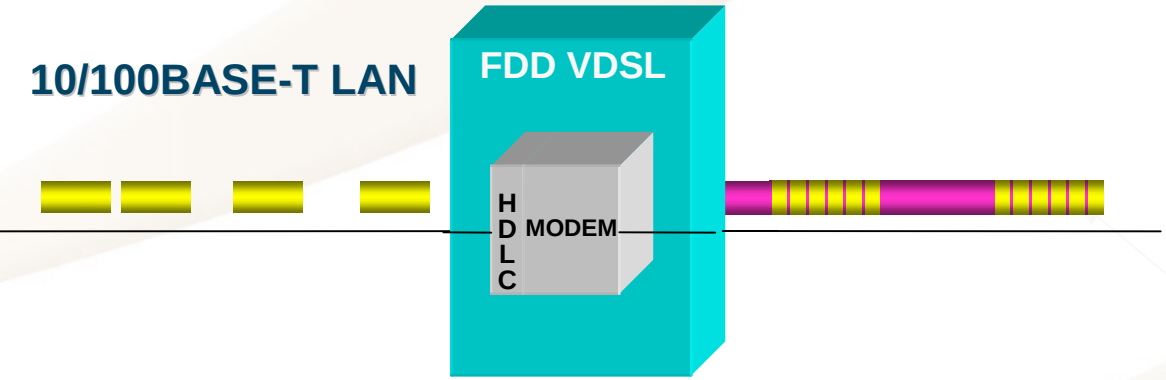
Why Consider this proposal?

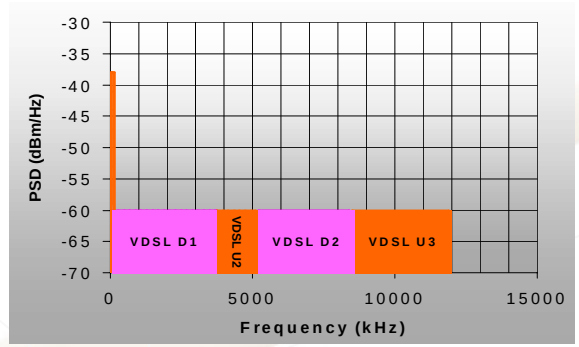
- **PHY Driven by Market Requirements**
  - Service Providers Want to Deliver Bandwidth Intensive Services
  - Need the Reach Required to Get to the Customer
  - Want Flexible Symmetry to Deploy the Broadest Applications
  - *Multi-Mode PHY Provides One Solution to Meet All Objectives*
- **A Multi-vendor Technology: Supports Free Market Competition**
- **Advances the State of the Art**

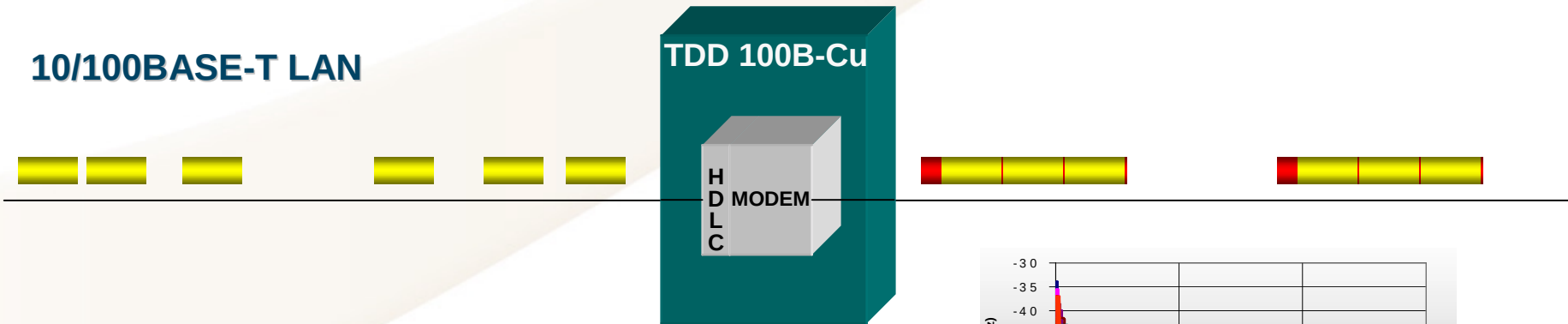
100BASE-Cu *Dual-Mode* Component Technologies

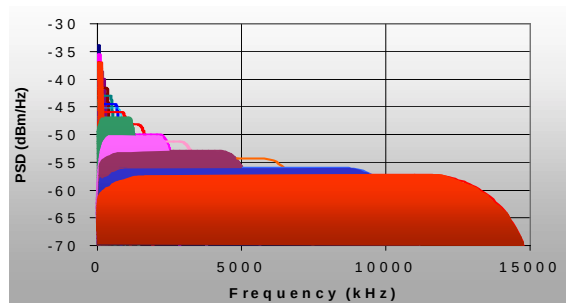
- **100BASE-Cu *Dual-Mode* allows the Application to decide which attributes are most important**
  - FDD
    - Short Reach
    - Fixed Symmetry
    - Not self-NEXT Limited
    - Constant latency
  - Dynamic TDD
    - Long Reach
    - Flexible Symmetry Ratios
    - Automatic Spectral Compatibility
    - Statistical Advantage in a High Crosstalk Environment

100BASE-Cu *Dual-Mode* Component Technologies

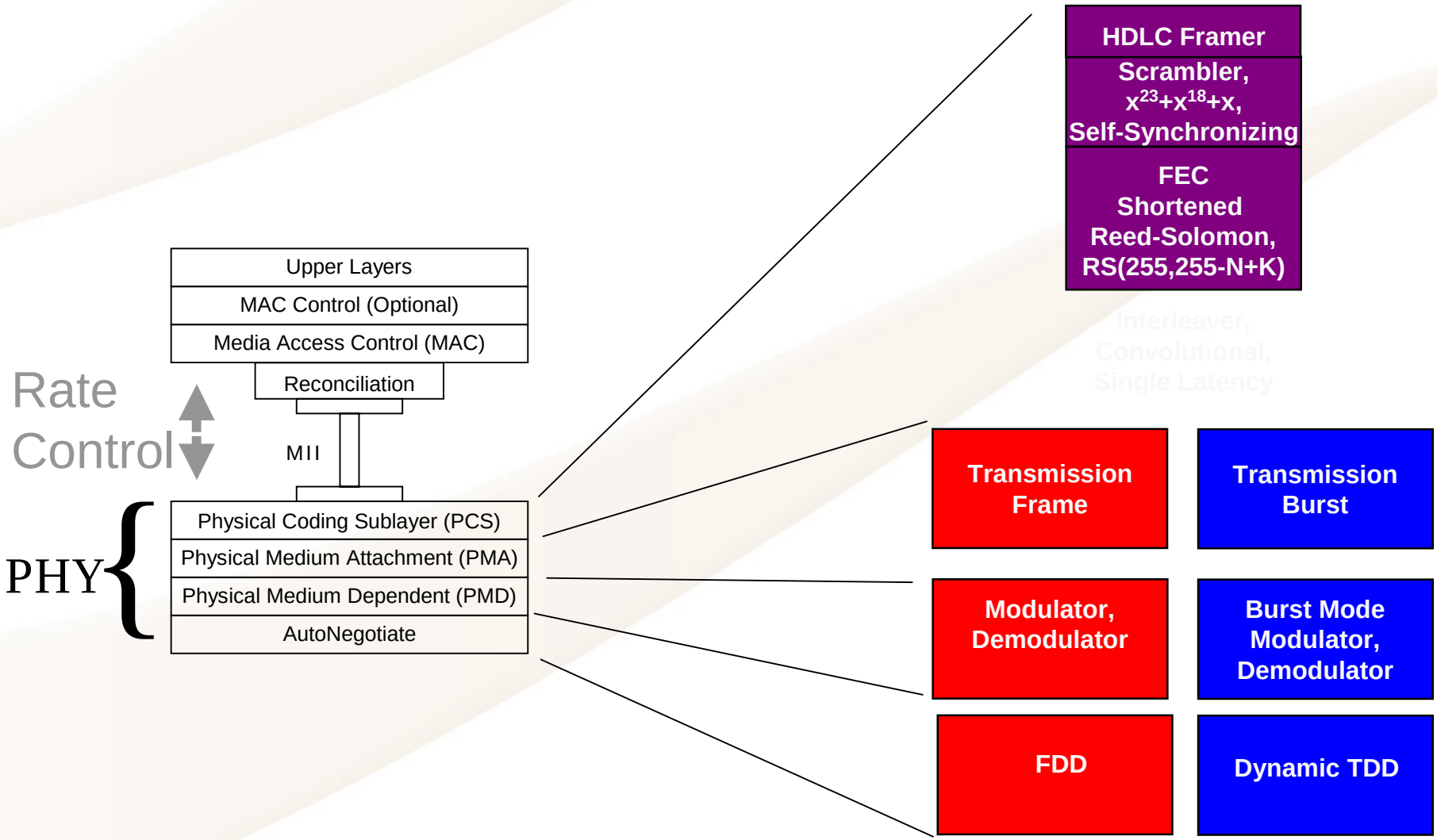






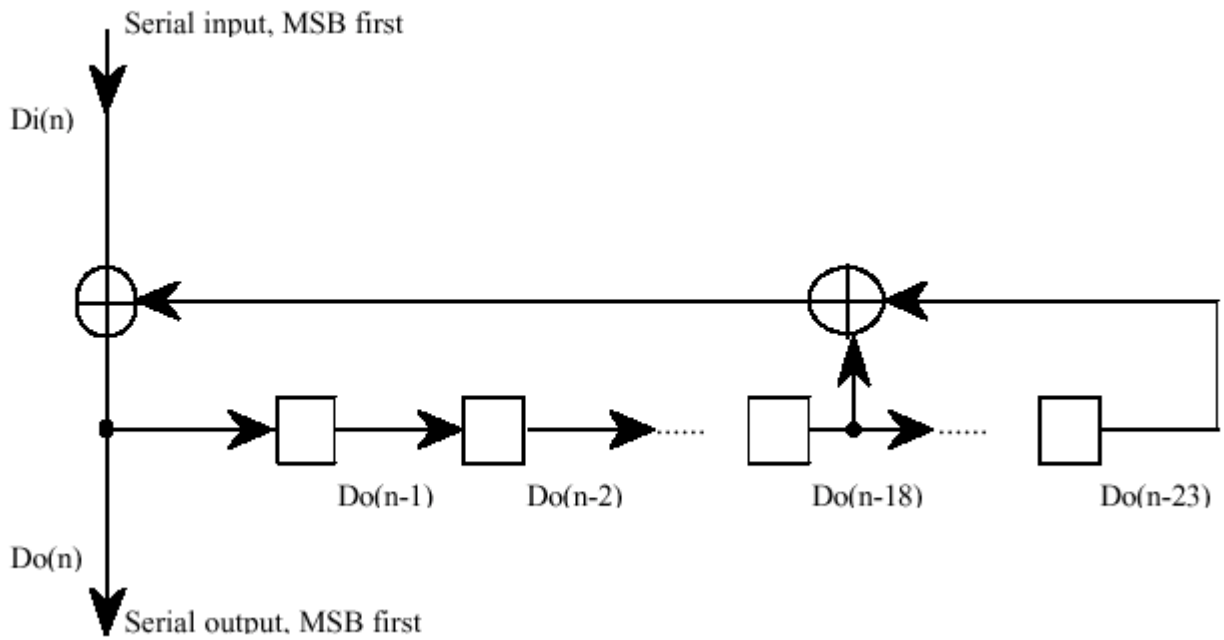


100BASE-Cu Dual Mode Layer Model



Scrambler, $x^{23}+x^{18}+x$

- **Self Synchronizing**



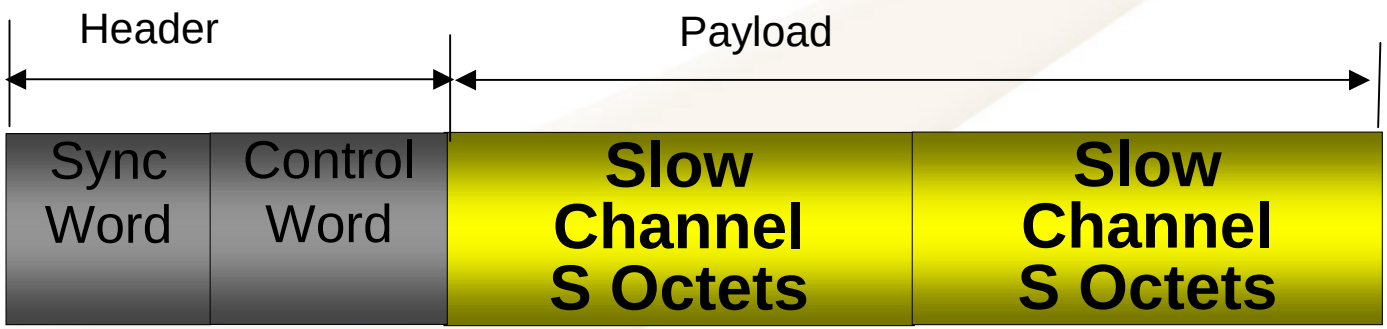
FEC

- **Shortened Reed Solomon RS(255,255-N+K)**

- **Codeword Length, N = 200 Octets, Data Length, K = 184 Octets => 16 Redundancy Octets = Can correct a maximum of 8 Octets per block**

100BASE-Cu FDD Mode Frame

PMS-TC Transmission Frame
Format per draft trial use
VDSL standard



Single Latency, optional Fast Channel not used
(Or us fast channel with second MII?)

100BASE-Cu TDD Mode Superframe (Burst)

100BASE-Cu Burst:

1 to 256 PMS-TC Frames per Burst (Superframe) Max

HDLC Frames concatenated into burst

Preamble: 128 Baud BPSK, 7 Byte Header

- **Preamble contains BPSK for timing recovery**
- **HDLC uses byte insertion**
- **Superframe header, which reports buffer fill, piggybacks onto user data bursts**

100BASE-Cu Superframe

- **PMS-TC framing per VDSL Trial Use Standard**
- **Superframe with a special header added to support TDD**
  - 128 BPSK symbols for timing recovery
  - 7 byte superframe header
  - 1 to 256 standard PMS-TC frames
  - Clear EOC protocol as specified in G.997.1

Convolutional Interleaver

S – incoming codeword length

I – interleaver block length, octets

D – interleaving depth, octets

M – interleaving depth index

Parameter	Value	Notes
Block Length (I)	I = S/8, S/4 or S/2, octets	S = 200
Depth(D)	D = M x I + 1, octets	M = 0 - 64, programmable
Erasure Correction (E)	E = floor[t x I/S] x (M x I + 1), octets	t = 8 (RS error correction ability)
End-to-End Delay (DL)	DL = M x I x (I-1), octets	
Interleaver Memory Size	MEM = M x I x (I-1)/2, octets	

- **D-1 octets separate any 2 sequential octets in RS codeword**
- **E sequential octets correctable, so noise pulse of duration Ex8/R, where R = bit rate, is protected against.**
- **Examples at 100Mbps:**
  - Minimum protection: M = 0 disables interleaver, 0.32uSec protection
  - Maximum protection: M = 64, I=S/2, 2mSec protection.
    - Costs: 50mSec Latency, 512KB of memory

100BASE-Cu Dual Mode Provision or Auto

- **Proposed Operational Modes (others may be suggested)**
  - Auto-Sense
    - Operates in Dynamic TDD mode, with Spectrum Manager listening for coupling with 988 plan (Additional provisionable option can limit Upstream frequency range to favor asymmetric service, heavier on downstream)
    - When coupled with 998 plan, switches to EoVDSL-like FDD, with Spectrum Manager listening for opportunity to switch back to dynamic TDD
  - Provisionable (Handshake procedure - G.994.1?) – Service Provider can provision to FDD mode or Dynamic TDD only mode
  - Reach extension
    - When Operating in FDD mode, automatically switches to dynamic TDD mode for long loops > 4-6Kft (Estimate Loop Length - Handshake procedure - G.994.1?)

Dynamic Symmetry Mechanism

- **FIFO builds burst from incoming packets in each direction**
- **If user traffic demand is symmetric, then both directions use full bursts – symmetric bandwidth on loop (if provisioned for symmetry service)**
- **If user traffic demand is heavily in one direction, that direction has full bursts, and return path has minimum bursts containing ACKs and status information**

Summary

- **This Proposed PHY Will Meet *All* of the EFM Copper Objectives:**
  - PHY for single Pair Non-loaded Voice Grade Copper, Distance >= 2500 Feet With >= 10mbps Aggregate Bit Rate
  - PHY for Single Pair Non-loaded Voice Grade Copper, Distance >= 4600m, 0.4mm >= 256kbps *(Can achieve 1Mbps for self-disturber case)*
  - PHY for Single Pair Non-loaded Voice Grade Copper, Distance >= 3700m, 0.5mm >= 4mbps
  - Can support optional specification for combined operation on multiple copper pairs
  - The point-to-point copper PHY is Compliant with spectrum management restrictions imposed by operation in public access networks, including: Recommendations from NRIC-V (USA), ANSI T1.417-2001 (for frequencies up to 1.1MHz), Frequency plans approved by ITU-T SG15/Q4,T1E1.4 and ETSI/TM6
- **Offers the Service Provider the Most Flexible Solution**