

EFM Copper

Objectives

EFM May, 2003

**Hugh Barrass (Cisco Systems),
Vice Chair. IEEE 802.3ah EFM Task Force**

Cu Objectives

- **Rate / Reach Objectives**

PHY for single pair non-loaded voice grade copper
distance $\geq 750\text{m}$ and speed $\geq 10\text{Mbps}$ full-duplex

PHY for single pair non-loaded voice grade copper
distance $\geq 2700\text{m}$ and speed $\geq 2\text{Mbps}$ full-duplex

- **PMI Aggregation**

Include an optional specification for combined operation
on multiple copper pairs

The Other Objective

- **Spectral Compatibility**

The point-to-point copper PHY shall recognize spectrum management restrictions imposed by operation in public access networks, including:

- o Recommendations from NRIC-V (USA)
- o ANSI T1.417-2001 (for frequencies up to 1.1MHz)
- o Frequency plans approved by ITU-T SG15/Q4, T1E1.4 and ETSI/TM6

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Technical Overview

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Technical Overview

- **The Components of the Standard**

Introduction - Hugh

EFM developed features - Hugh

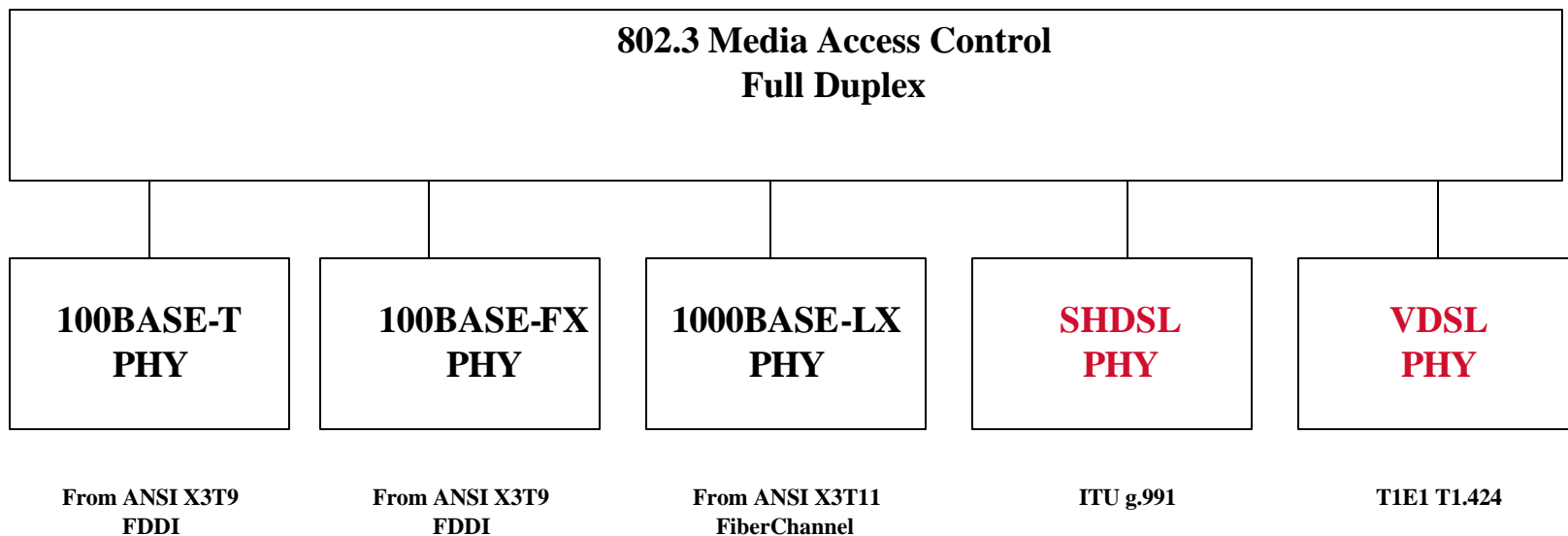
SCM technical recap - Steven

MCM technical recap - Behrooz

Summary - Barry

An Ethernet Tradition

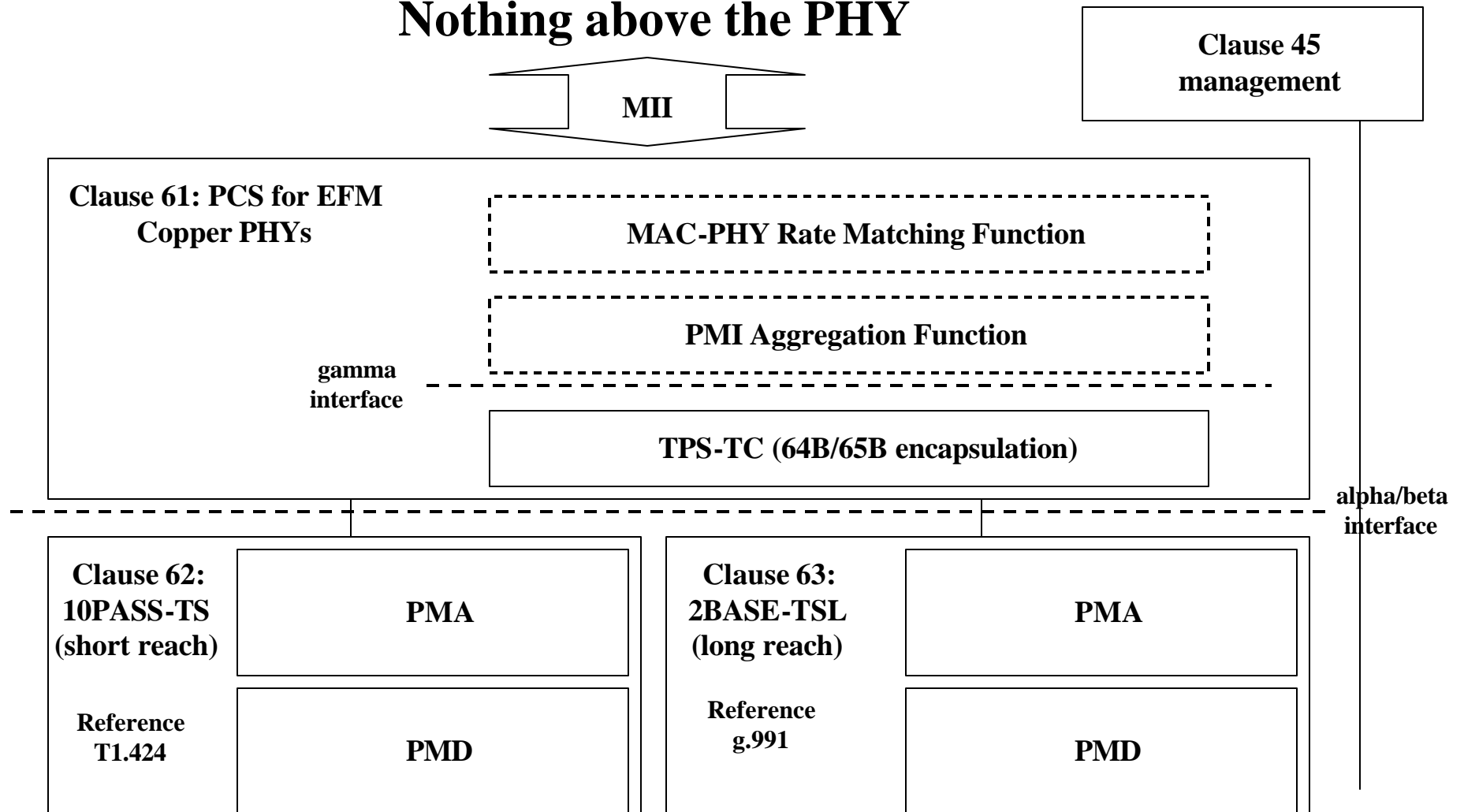
Historical precedent – use existing PHY



- Builds on known working Physical Layer (historical precedent)
- Ethernet “value add” – simple & low cost
- Two DSL PHYs imported for EFM Copper

The EFM Cu Clauses

Nothing above the PHY



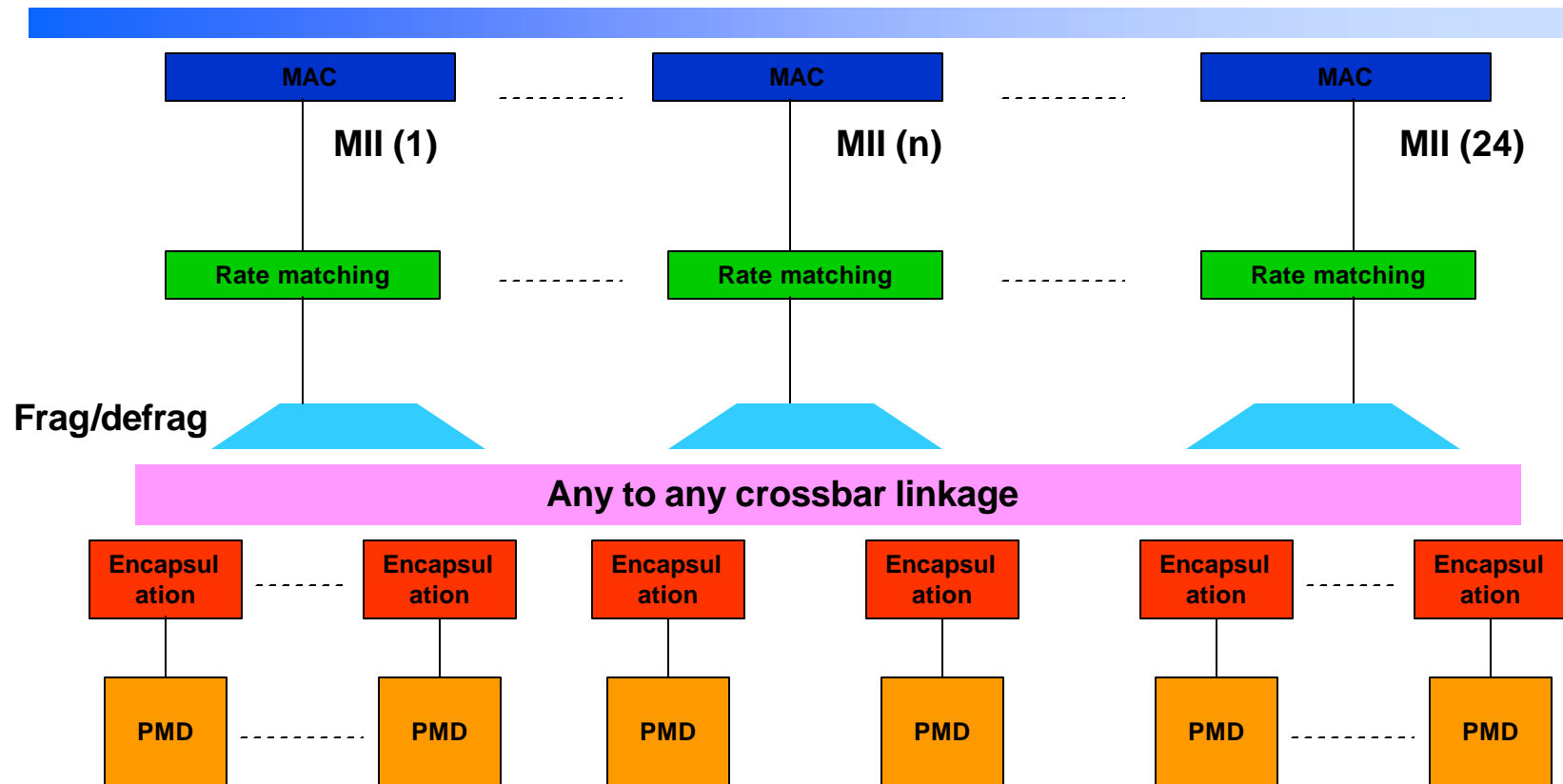
The “EFM Additions”

- **All of Clause 61**
 - MAC-PHY Rate Matching**
 - PMI Aggregation**
 - 64byte/65byte encapsulation**
 - Handshaking (our own tree based on g.hs)**
- **Other Stuff**
 - PMA Enhancements: PAM-32, QAM-4096**
 - Management: Tone Group Control Register**

MAC-PHY Rate Matching

- **Use Deference (false CRS)**
 - MII @ 100Mbps, MAC in half duplex mode
 - Transmit paused when CRS held asserted
 - Needs full frame Tx + Rx buffering
 - Most MACs can receive while transmitting
- **Advantages**
 - 100Mbps full duplex
 - No Pause frames – PHY doesn't generate frames
 - Closed loop – copes with any (aggregated) data rate
 - Runs with std clocks – good for multi-MAC devices
 - No changes to current MAC silicon

PMI Aggregation Function



- Any connection between MII's and PMI's
- Implementation could use arbitrary number of MII's vs PMI's
- System vendor could choose optimal ratio

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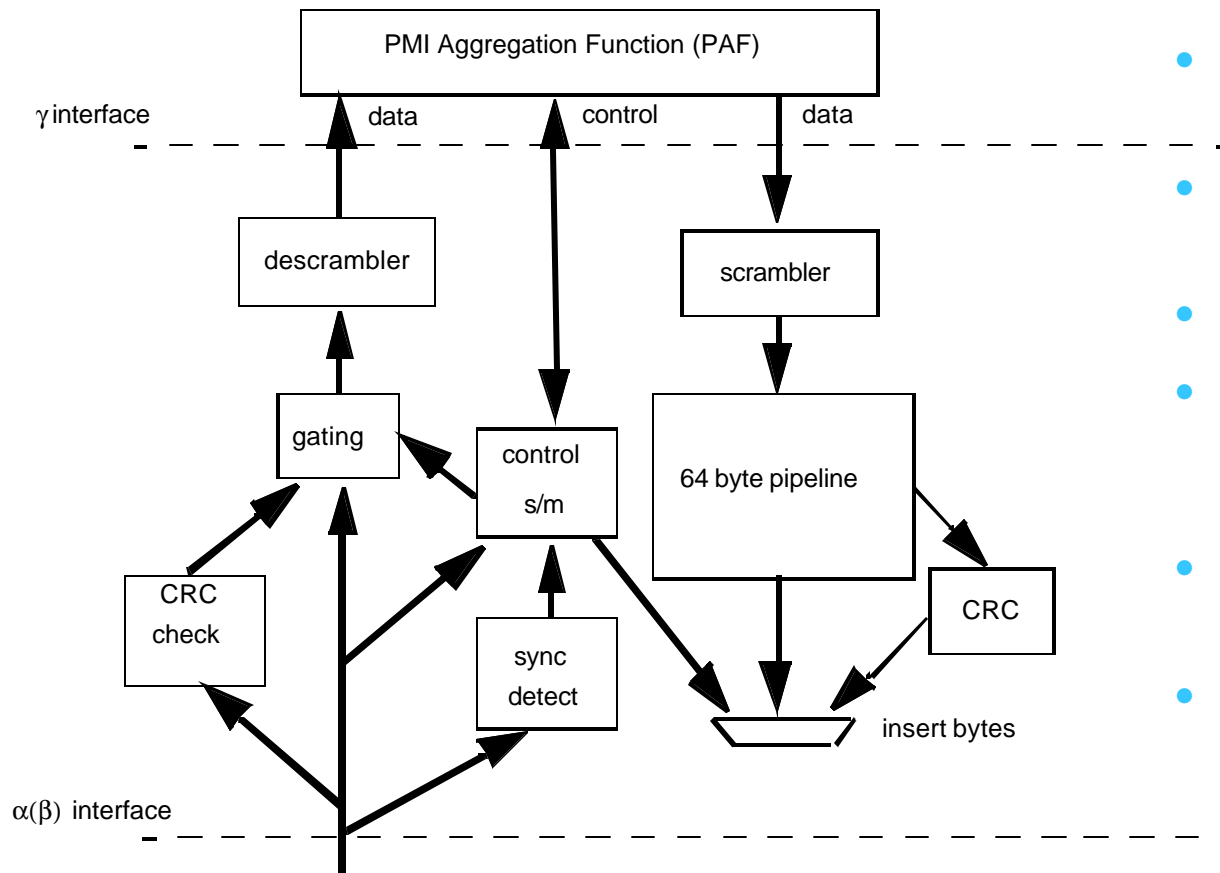
Needs fragmentation

SequenceNumber (14 bits)	StartOfPacket (1 bit)	EndOfPacket (1 bit)	Fragment Data
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- Details of algorithm unconstrained – allows innovative implementation
- Constraints placed on min / max fragment size and ...
- ... maximum differential latency
- Robust definition allows frames to continue after single link loss without intervention

Lets OAM find cause of failure

TPS-TC & Encapsulation



- **Transport Protocol Specific – Transmission Convergence**
- **Identify packet delineation over byte stream**
- **Use 64byte/65byte**
- **Constant overhead – no data dependence (good for QOS/SLA)**
- **Minimal buffering – not frame oriented**
- **Fast lock after link interruption**

64byte/65byte encapsulation

- Similar in principle to 64/66 – but byte oriented
- <2% overhead
- Don't transport IPG & preamble – frame-to-frame with no Z allowed

Type	Frame Data	Sync byte	Byte fields 1-64									
All data	DDDD---DDDD	OF ₁₆	D ₀	D ₁	D ₂	D ₃	D ₄	D ₅	...	D ₆₁	D ₆₂	D ₆₃
End of frame	Contain k D's where k=0 to 63	FO ₁₆	C _k	D ₀	D ₁	D ₂	D ₃	...	D _{k-1}	Z	...	Z
All idle	ZZZZ---ZZZZ	FO ₁₆	Z	Z	Z	Z	Z	Z	...	Z	Z	Z
Start of frame while idle	Contain k D's, where k=0 to 63, and contains j Z's where j=63 - k	FO ₁₆	Z	Z	S	D ₀	D ₁	D _{k-3}	D _{k-2}	D _{k-1}
Start of frame while trans-mitting	Contains last k D's of 1 st frame, where k=0 to 62; & first j D's of 2 nd frame, where j= 0 to 62	FO ₁₆	C _k	D ₀	...	D _{k-1}	Z	...	S	D ₀	...	D _{j-1}

Summary

- **Clause 61 hooks Ethernet MAC to DSL PHYs**
 - Designed as “best solution” for Ethernet
 - Uses standard DSL interfaces (alpha/beta, gamma)
 - Defined for VDSL & SHDSL
 - Liaise into ITU for use by any DSL PHY
- **Other innovations**
 - Increased data rates with larger constellations
 - Straightforward and logical progression
 - Tone group control register (for DMT)
 - Allows ultimate flexibility for tone control
 - Simple and compact interface
 - Write your name in tones