EFM Copper PHY Status: Ready for WG Ballot

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Copper Clauses Satisfy PAR

- **Title:** Media Access Control Parameters, Physical Layers and Management Parameters for subscriber access networks
- **Scope:** Define 802.3 Media Access Control (MAC) parameters and minimal augmentation of the MAC operation, physical layer specifications, and management parameters for the transfer of 802.3 format frames in subscriber access networks at operating speeds within the scope of the current IEEE Std 802.3 and approved new projects
- **Purpose:** To expand the application of Ethernet to include subscriber access networks in order to provide a significant increase in performance while minimizing equipment, operation, and maintenance costs
  - **Clauses 61- 63 define new copper PHYs for subscriber access networks**
  - **Copper PHYs use existing 802.3 MAC**
  - **Clause 45 includes Management Parameters for copper PHYs**
  - **Clause 61- 63 PHYs include operation from 1 Mb/s to 100 Mb/s; within the scope of the current standard**
  - **New Ethernet copper PHYs provide significant cost/performance advantages over existing non-Ethernet DSL equipment**

Copper Clauses Satisfy 5 Criteria - Broad Market Potential

- Broad sets of applicability
  - Subscriber access network unloaded copper loops number in 100's of millions
  - Copper PHYs also applicable to campus/private networks.
- Multiple vendors and numerous users
  - Multiple vendors exist for both SHDSL-PAM (2BASE-TL) and VDSL-DMT (10PASS-TS) technologies
  - Analysts forecast >32 Million EFM Copper users by 2006*
- Balanced costs (LAN versus attached stations)
  - Existing DSL systems demonstrate a feasible network access equipment cost vs. typical attached stations
  - EFM Copper PHYs will further enhance this feasibility by building on DSL technology and adding Ethernet's lower overall installation and maintenance costs.

*In-Stat/MDR, *Ethernet in the First Mile (EFM): Like A Bridge Over Troubled Waters*, Nov. 2002

Copper Clauses Satisfy 5 Criteria - Compatibility

- Conformance with 802 Overview and Architecture
  - As a supplement to IEEE Std 802.3, Clauses 61-63 remain in conformance with the 802 Overview and Architecture
    - e.g., comply with Clause 7 BER* and undetected error requirements
- Conformance with 802.1D, 802.1Q, 802.1f
  - As a supplement to IEEE Std 802.3, Clauses 61-63 remain in conformance with 802.1D (MAC Bridges), 802.1Q (VLANs) and 802.1f (Common Management Info & Procedures)
- Compatible managed object definitions
  - Clause 45 additions for 2BASE-TL and 10PASS-TS follow the existing format and structure of 802.3 MIB definitions.

*see Backup slides

Copper Clauses Satisfy 5 Criteria – Distinct Identity

- Substantially different from other IEEE 802 standards
  - There is no other existing 802 standard or approved project appropriate for voicegrade copper that meets the spectrum compatibility regulatory requirements for the public access network
- One unique solution per problem (not two solutions to a problem)
  - Each distinct copper rate/reach objective has one and only one PHY specified
- Easy for the document reader to select the relevant specification
  - Performance guidelines in normative Annex 62B (for 10PASS-TS) and normative Annex 63B (for 2BASE-TL) assist the reader in selecting the appropriate PHY for the target rate and reach

Copper Clauses Satisfy 5 Criteria – Technical Feasibility

- Demonstrated system feasibility
  - EFM Cu PHYs build upon the proven Ethernet network architecture, a system with well-demonstrated feasibility
- Proven technology, reasonable testing
  - The DSL-based PMDs are used in millions of access network connections
  - Test criteria and procedures are well-known
- Confidence in reliability
  - New 64B/65B Ethernet frame encapsulation using in 2BASE-TL and 10PASS-TS ensure very high MTTFPA

Copper Clauses Satisfy 5 Criteria – Economic Feasibility

- Known cost factors, reliable data; Reasonable cost for performance
  - 2BASE-TL:
    - low-complexity (cost), high-volume mature PMD
    - Similar cost to ADSL (see kimpe_copper_1_0103)
    - ~5% annualized cost decline forecast for 2001-2006*
  - 10PASS-TS:
    - Cost-effective short-reach PMD (see rezvani_1_0603 slides 23-26)
    - ~4% annualized cost decline forecast for 2001-2006*

*In-Stat/MDR, *Back From The Brink: The DSL IC Market Returns To Growth in 2002 After Tough 2001*, July 2002

Copper Clauses Satisfy 5 Criteria – Economic Feasibility (*cont'd*)

- Consideration of installation costs
  - Ethernet network provides lowest possible installation, provisioning, and maintenance costs
  - Compatibility of 10PASS-TS with existing ADSL base provides efficient upgrade path
    - Low complexity of 2BASE-TL allows it to be implemented in same device as well
  - Inherent flexibility of 10PASS-TS allows easy configuration to regional spectrum requirements

Copper Clauses Satisfy Objectives

- Support subscriber access network topologies
  - Point to point on copper
    - **Clauses 61-63 and associated Annexes define 10PASS-TS and 2BASE-TL point to point copper PHYs**

Copper Clauses Satisfy Objectives

- Provide a family of physical layer specifications
  - for single pair non-loaded voice grade copper distance ≥750m and speed ≥10Mbps full-duplex
    - 10PASS-TS: Clauses 61 & 62 & Annexes
    - Table 62B-1 specifies requirement for 10Mbps @ 750m; meeting Objective

Copper Clauses Satisfy Objectives

- Provide a family of physical layer specifications (*cont'd*)
  - PHY for single pair non-loaded voice grade copper distance ≥2700m and speed ≥2Mbps full-duplex
    - 2BASE-TL: Clauses 61 & 63 & Annexes
    - Subclause 63B.4 specifies requirement for 2048Kbps @ 2.8Km; exceeding Objective

Copper Clauses Satisfy Objectives

- Include an optional specification for combined operation on multiple copper pairs
  - Clause 61 contains specification for optional aggregation sublayer

Copper Clauses Satisfy Objectives

- The point-to-point copper PHY shall recognize 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)
    - 2BASE-TL PSDs comply with T1.417 & NRIC-V
    - 10PASS-TS PSDs comply with T1.417 & NRIC-V when configured for Plan 998
  - Frequency plans approved by ITU-T SG15/Q4, T1E1.4 and ETSI/TM6
    - 2BASE-TL and 10PASS-TS bandplans include those recognized by these 3 SDOs

Summary

- Copper clauses in draft specify PHYs that meet TF PAR, 802 LMSC 5 Criteria, and EFM TF Objectives for Copper
- Copper clauses are technically complete
- We are ready for WG Ballot

Backup

802.0 Clause 7 BER Requirement

- 7 General requirements for an 802 LAN or MAN
  - 7.3 Error Rates

    "For wired or optical fiber physical media: Within a single access domain, the probability that a transmitted MAC frame (excluding any preamble) is not reported correctly at the Physical Service interface of an intended receiving peer MAC entity, due only to operation of the Physical layer, shall be less than ***8×10^{-8}*** *per octet of MAC frame length."*
- Do 10PASS-TS and 2BASE-TL Comply?

802.0 Clause 7 BER Requirement (*cont'd*)

- Do 10PASS-TS and 2BASE-TL Comply?
  - From 61.1.2:

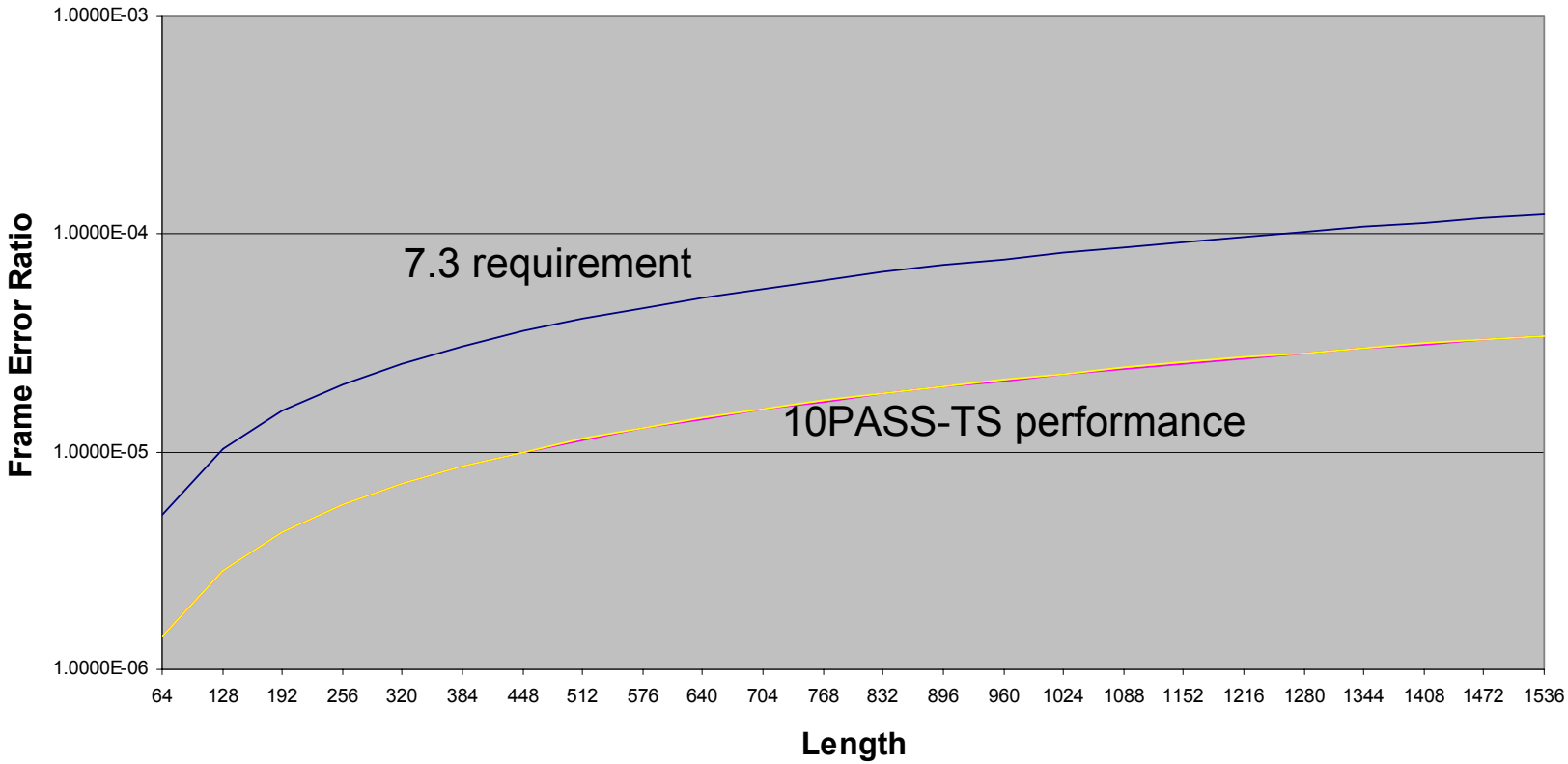
    d) To provide a communication channel with a mean BER at the PMA service interface of less than 10^{-7} with a noise margin of 6dB (10PASS-TS) or 5dB (2BASE-TL).
  - BER specification is higher,
  - But bit errors are not independent

802.0 Clause 7 BER Requirement (*cont'd*)

- 10PASS-TS
  - Bit errors not independent
  - Uncorrected errors contain ~9 errored bytes
  - ~4 errored bits per errored byte $\Rightarrow$36 errored bits per line error event
  - BER of $10^{-7} \Rightarrow$ 1 line error event per 360 million bits
  - 128×8=1024 bits per R-S codeword $\Rightarrow$ 2.84×10^{-6} codeword error ratio
  - 224×8=1792 bits per R-S codeword $\Rightarrow$ 5×10^{-6} codeword error ratio

802.0 Clause 7 BER Requirement (*cont'd*)

- These exceed Clause 7.3 requirements:



802.0 Clause 7 BER Requirement (*cont'd*)

- Similar analysis can be done for 2BASE-TL
  - Trellis coding + multiple bits/symbol produce non-independent bit errors
- In addition, specification of 5 dB & 6 dB noise margins ensure requirement is easily met