Gigabit Ethernet
taking
“Ethernet Everywhere®”

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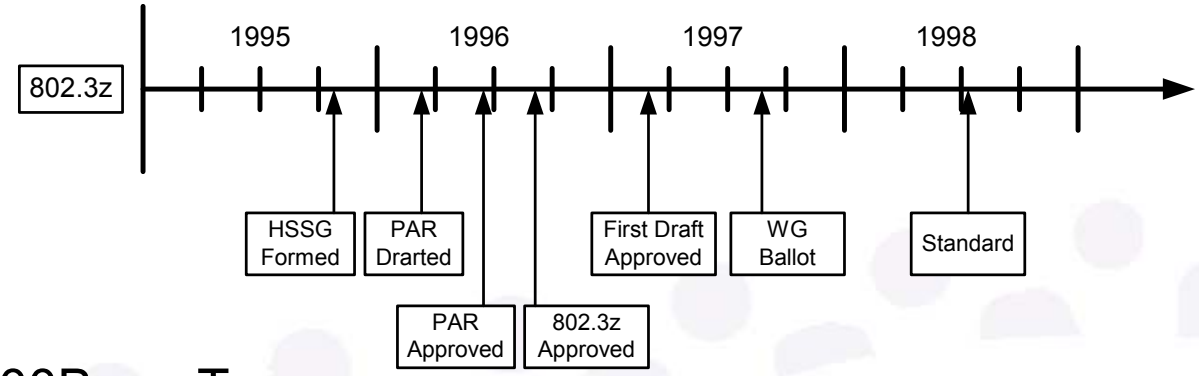
Agenda

- Standards background
- Cabling types and their applications
- Standards Extensions
- Interesting but unpopular diversions
- Industry Trends – product “generations”
- System Level Issues
- Migration to 10GE

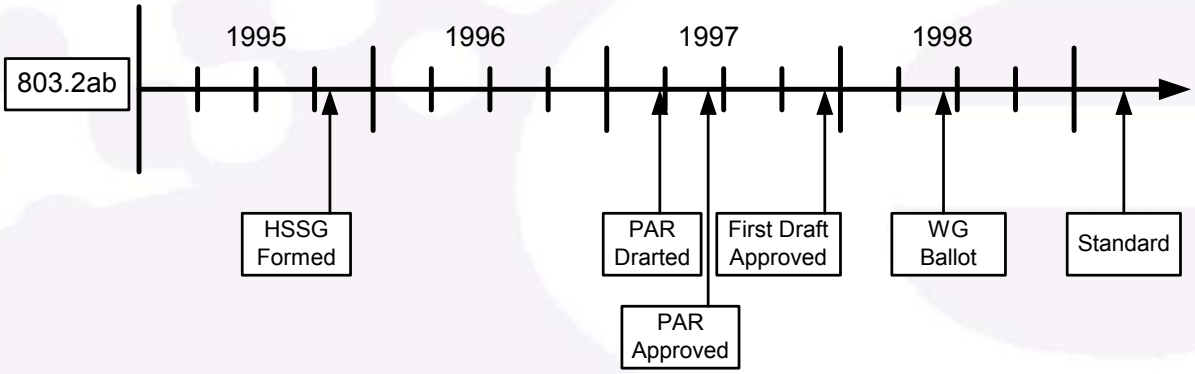
Alphabet soup (from ab to z)

Standards and Timelines

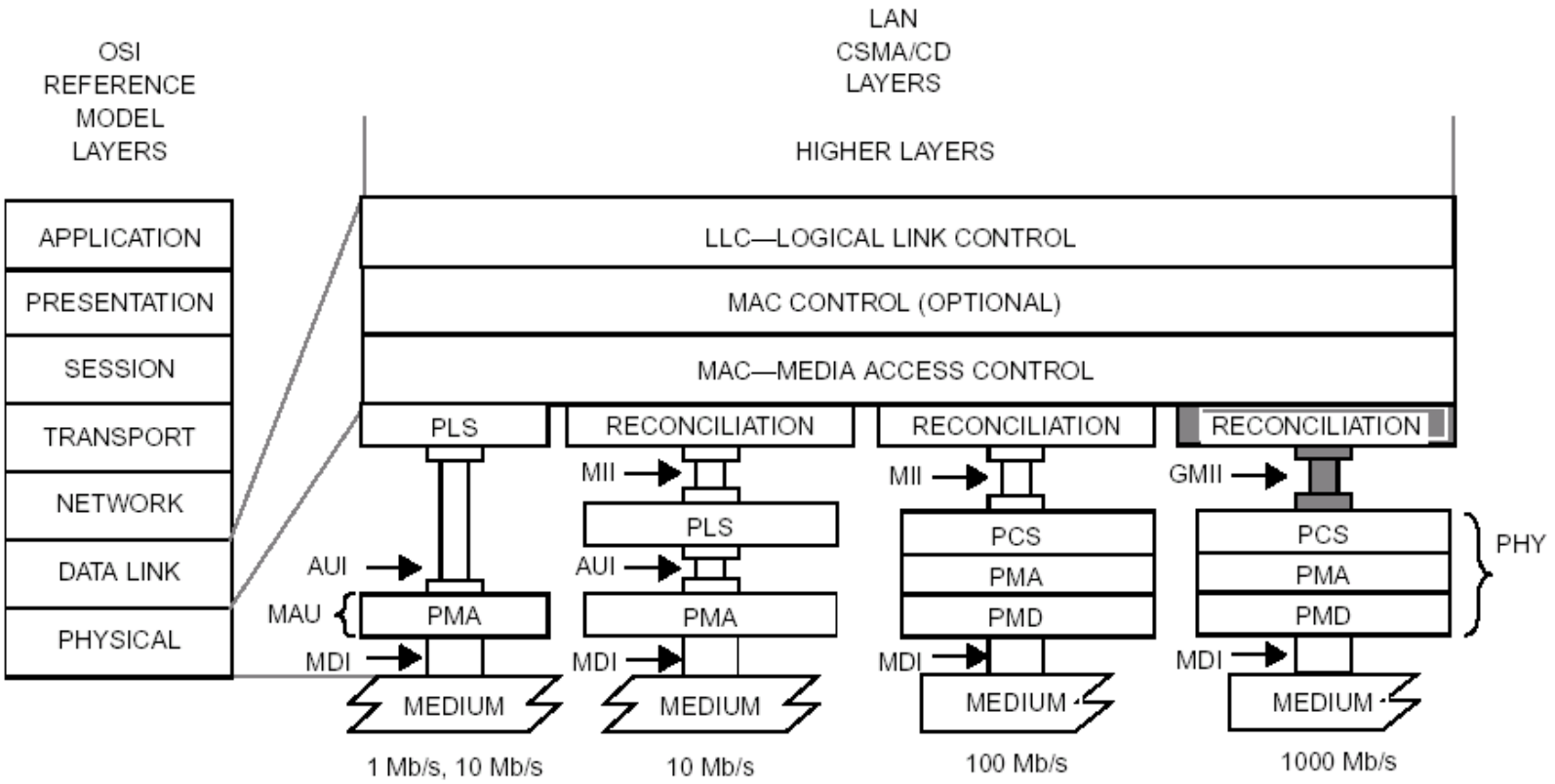
802.3z – 1000Base-X



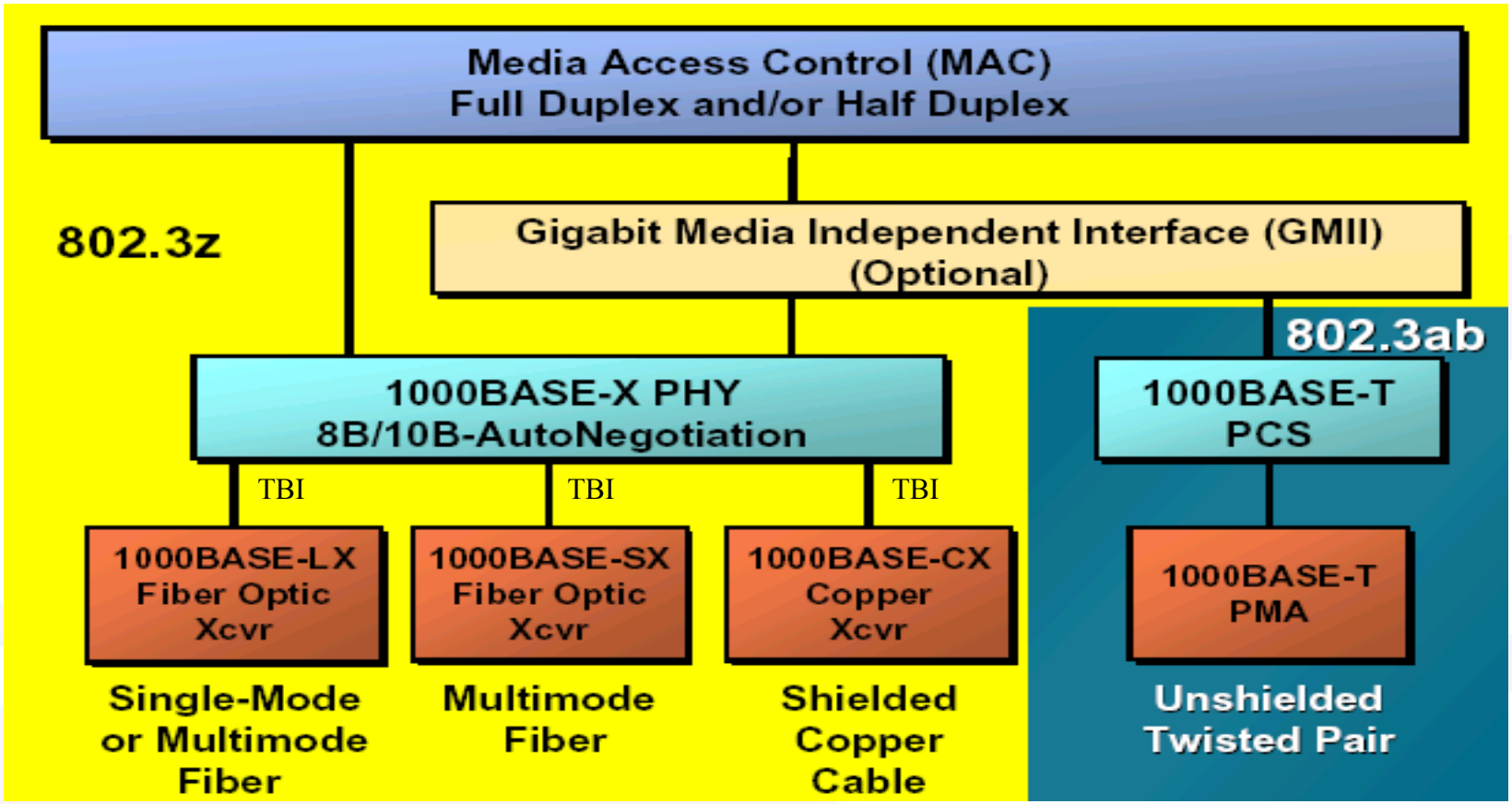
802.3ab – 1000Base-T



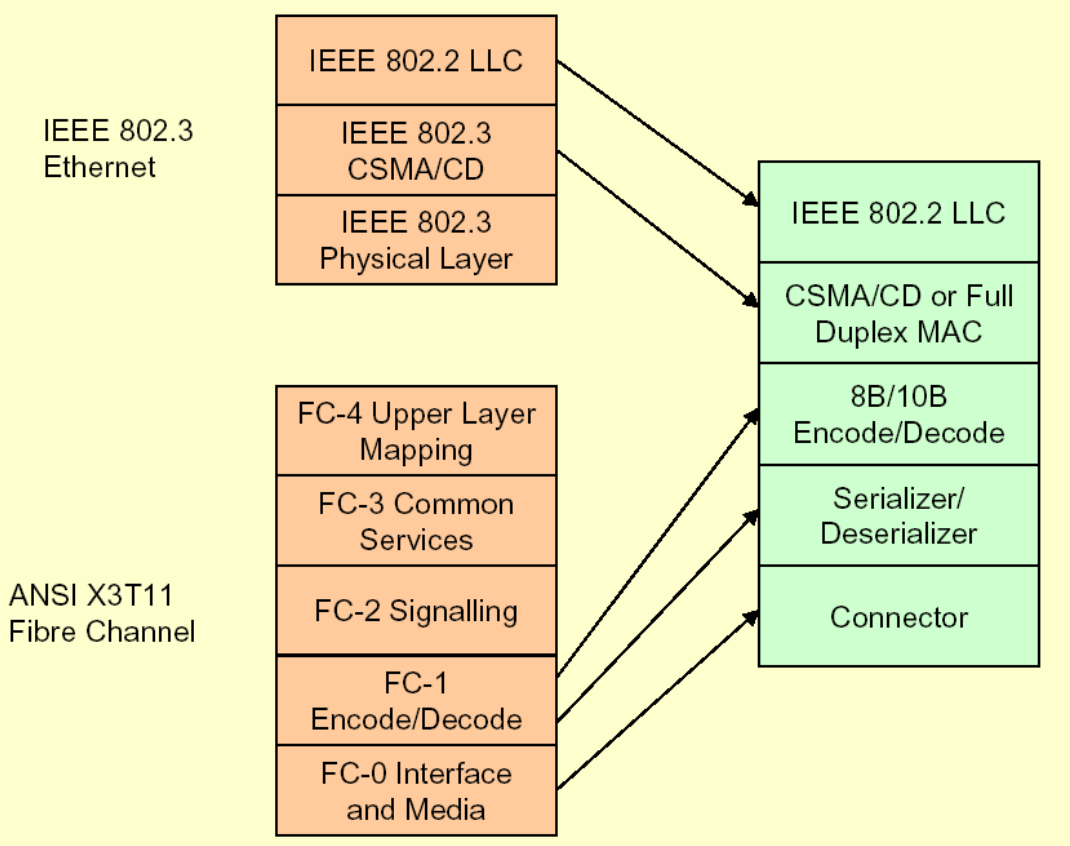
Ethernet 101



Media Types Supported



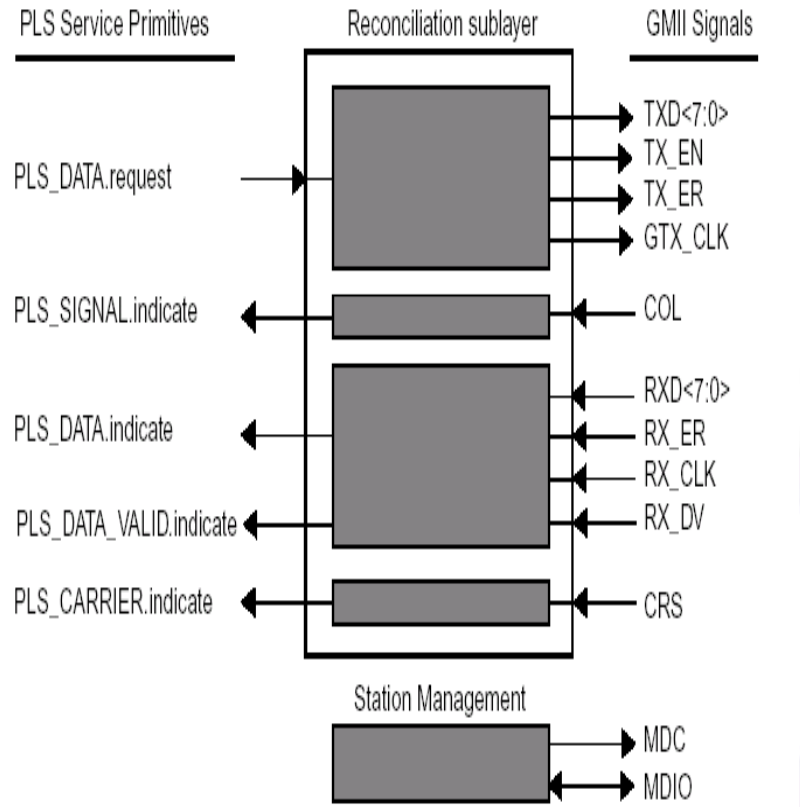
Gigabit Heritage



- ANSI Weds IEEE
- LLC and MAC came from Ethernet world
- PCS, PMD and PMA came from Fibre Channel.

Gigabit Ethernet 101

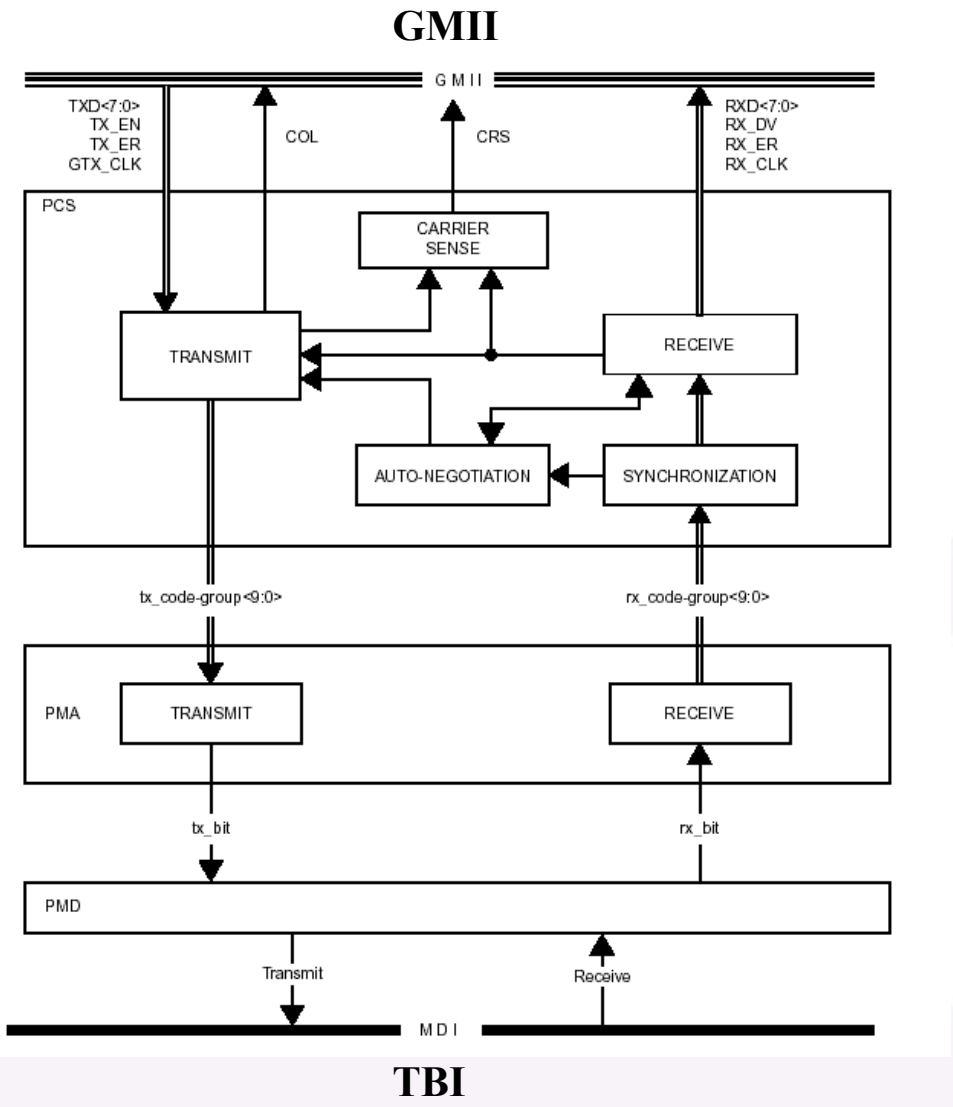
Reconciliation Sublayer – Clause 35



- 8 bits @ 125MHz
- Flexibility for future interfaces
- Interoperability between silicon vendors.
- Maps into TBI pins

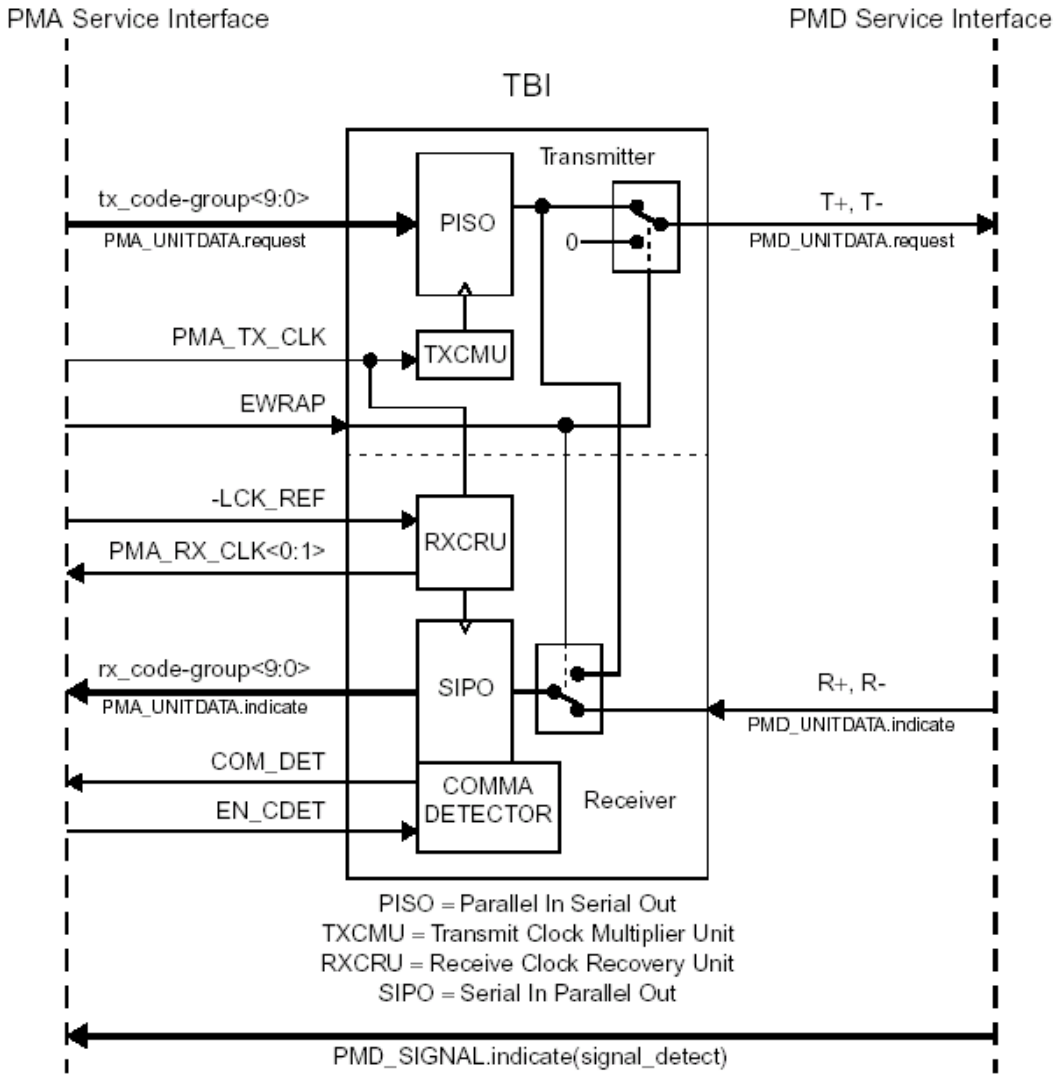
Physical Coding Sublayer – Clause 36

"TBI" Ten Bit Interface



- Borrowed from FC - 8b/10b developed at IBM.
- Transition density – good for CDR and ISI
- DC balance – running disparity
- Unique Comma code group
- TBI and Autoneg (Clause 37)
- Synchronization
- Not media independent - 1000base T uses PAM5

PMA – TBI to Serial. -Clause 36

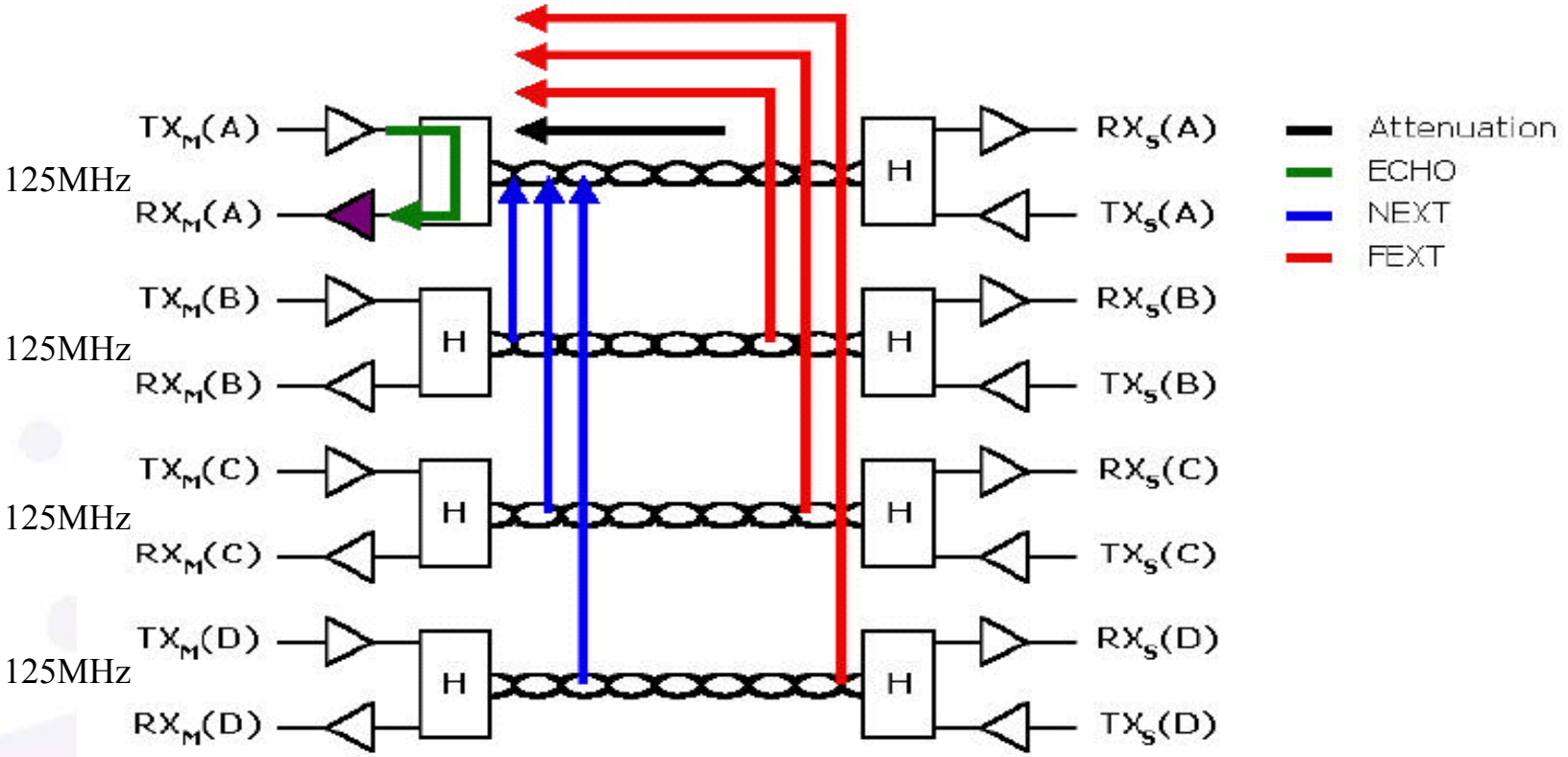


- Often called “SERDES”
- Comma detect.
- Word alignment.
- Loopback mode
- Test modes:
  - K28.7 Low Freq
  - D21.5 High Freq
  - K28.5 Mixed Freq
- Key building block derived from fiber channel

802.3ab Overview

- Full Duplex Gb/s data transmission over 4 pair Cat5 UTP
- Many challenges:
  - Insertion loss (Attenuation)
  - Return Loss (Reflection)
  - Bi-directional signaling (Echo)
  - Cross talk (Noise)
    - NEXT
    - FEXT
- Technology
  - Transmit and Receive on the same pair (Echo cancellation)
  - Use all 4 pairs simultaneously
  - PAM 5 (+2,+1,0,-1,-2) replaced MLT3 → 2 bits/baud
  - Combination of above reduced bandwidth to 125MHz (/2, /4, /2)
  - Use FEC to recover 6 db SNR
  - Digital Adaptive Equalization
- Powerful DSP approaches won over analog

802.3ab Overview



Auto Negotiation Evolution or Revolution

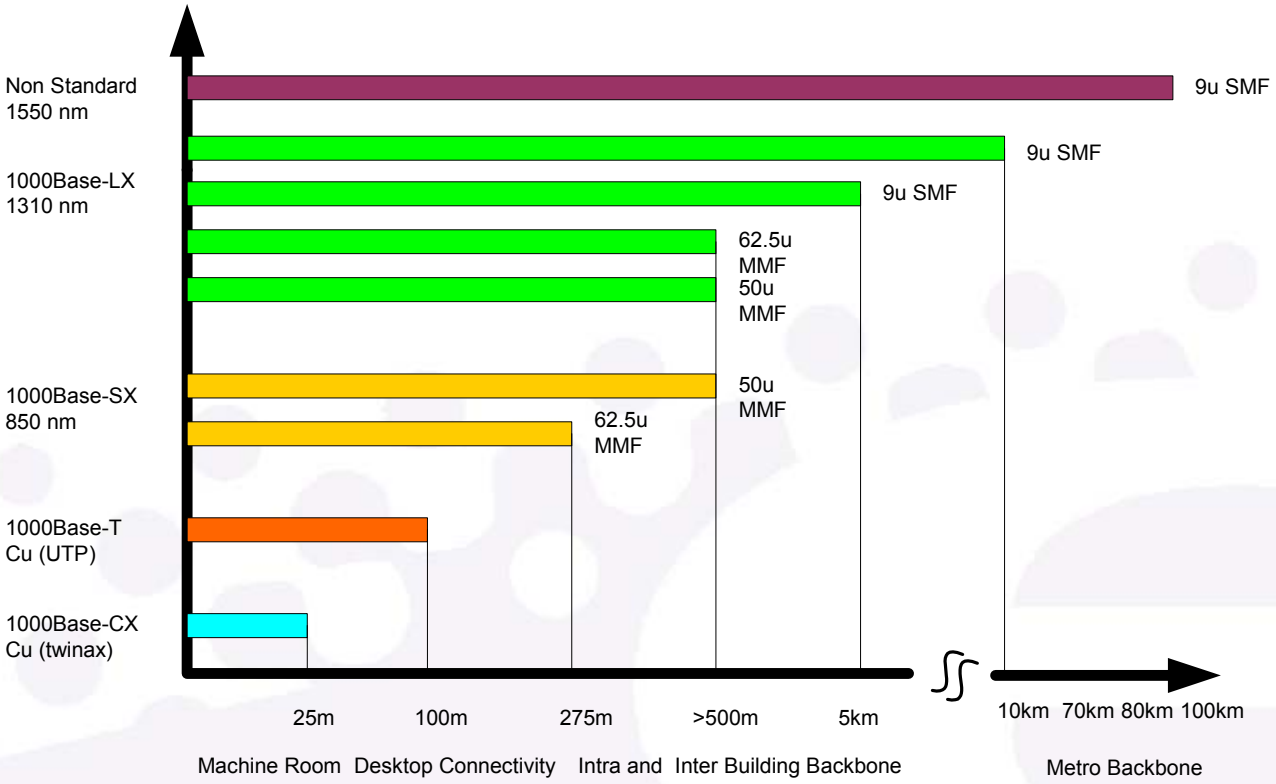
802.3ab – Clause 28, 40.5

- follows 10/100
  - FLP based
- Base Page
  - Speed
  - Duplex
  - Pause
- Next page capabilities
  - Master Slave

802.3z – Clause 37

- less complex
  - Fixed speed
  - Hand shake algorithm
- Base page
  - Duplex
  - Pause
  - Fault (unused)
- Next page (unused)

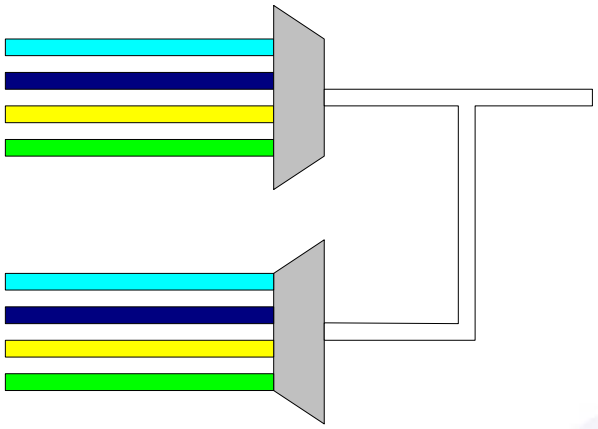
PMDs and their Applications



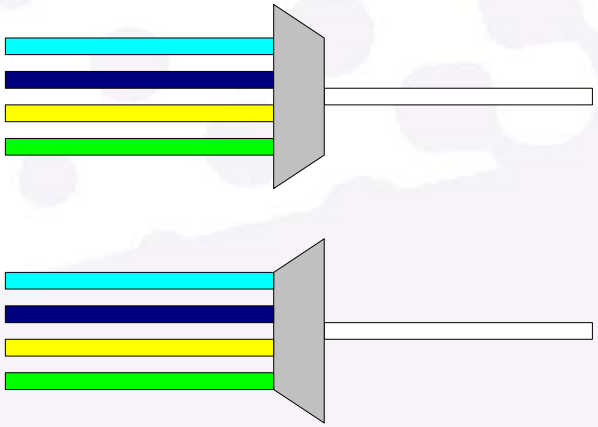
The GBIC - Gigabit Interface Converter
"your flexible friend"

- Common form factor for all PMDs
  - Lowered cost of ownership
- 1550 nm modules "breaking out of the campus"
  - More power
  - less loss
  - avalanche photo detectors
  - Matched to dispersion shifted fiber

WDM Extensions



Bi Directional Single Strand



Uni Directional Dual Strands

- Uncooled lasers
  - coarse WDM 8 wavelengths for higher information density per link
  - Similar technique employed to stripe data over multiple wavelengths to extend distance
- Cooled Lasers
  - Adoption of ITU grid wavelengths to co-exist in DWDM infrastructures

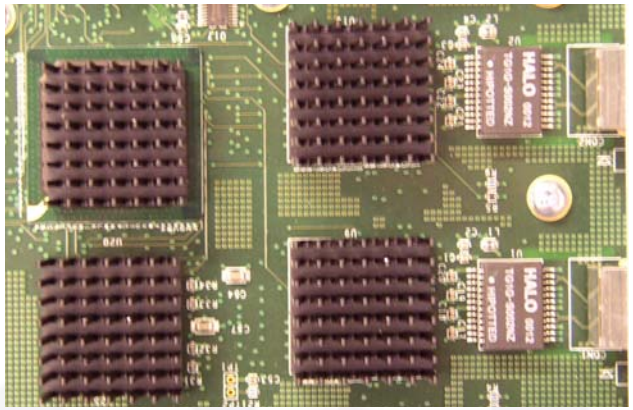
Good Ideas but ...

- Half Duplex support
  - Carrier extension, death of the repeater, rise of the switch
- Asymmetric flow control
  - Buffered Repeaters, where are they now?
- Jumbo Frames
  - 9k/16k MTU, who does the hard work?
- Short Haul copper (1000Base-CX)
  - structured wiring won

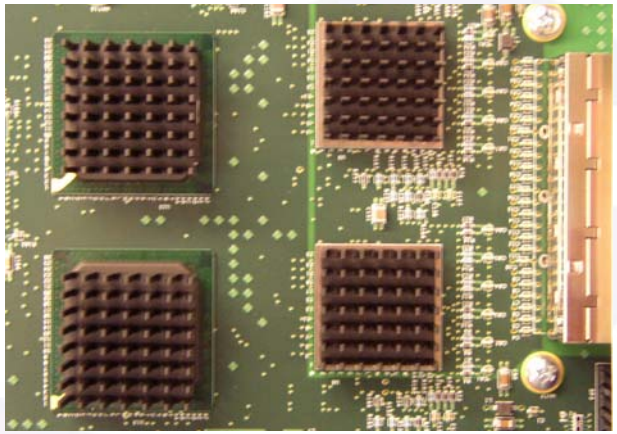
Industry Trends

- Optics
  - Form factor reduction
  - GBIC→ SFP
- Serialization of interfaces
  - GMII → RGMII→SGMII
  - TBI→ RTBI→integrated SERDES
- Integration
  - Greater Port Density
  - Constancy of Power
  - Increase in current

2 ports 1000Base-T 1999



8 ports 1000Base-T 2002



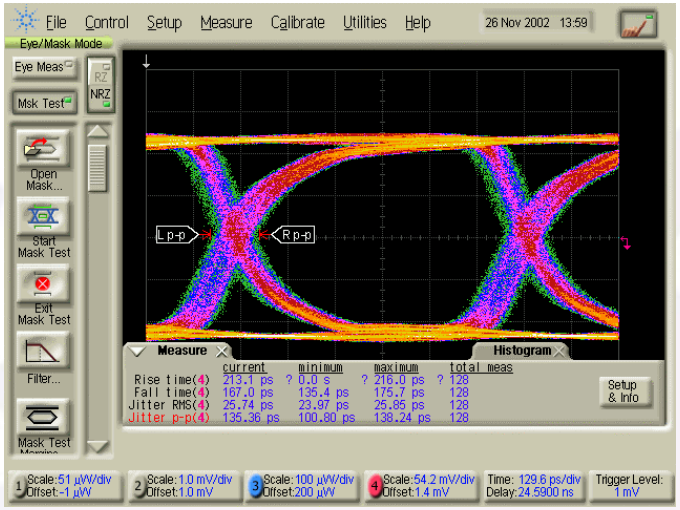
System level Problems

- Clocks – keep them cleaner than you closet
  - “garbage in – garbage out”
  - Pick the right source for you.
- Loop BW
  - Not knowing bandwidth of all PLLs involved can be a disaster.
- Signal Slew Rate
  - Test with min and max specified slew rate.
  - Faster silicon can cause package related problems to show up.
- Balancing Fidelity with Emissions
  - Crisp edges radiate more – strike a balance.
  - Terminate signals in some way.
- Signal Routing
  - Special attention to clocks and differential pairs to minimize crosstalk.
  - Consider Via discontinuities on thick boards.
  - Return currents are important. Low impedance is a good thing.

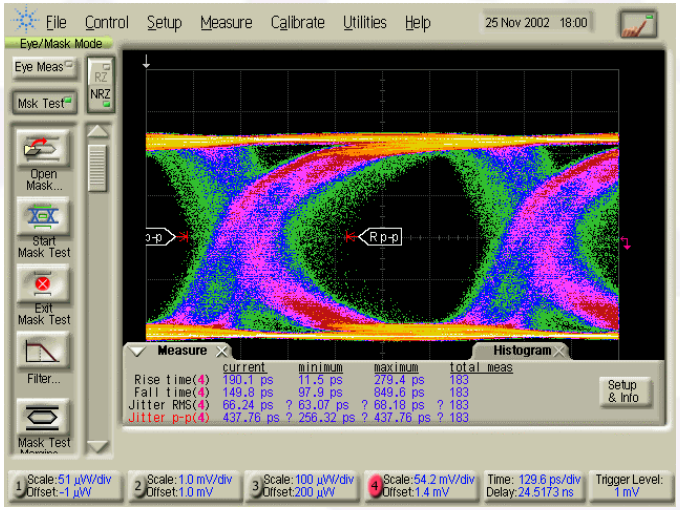
System level Problems

Supply plane Noise and glitches

- GBIC with Fiber and attenuation.
- Nominal VCC.

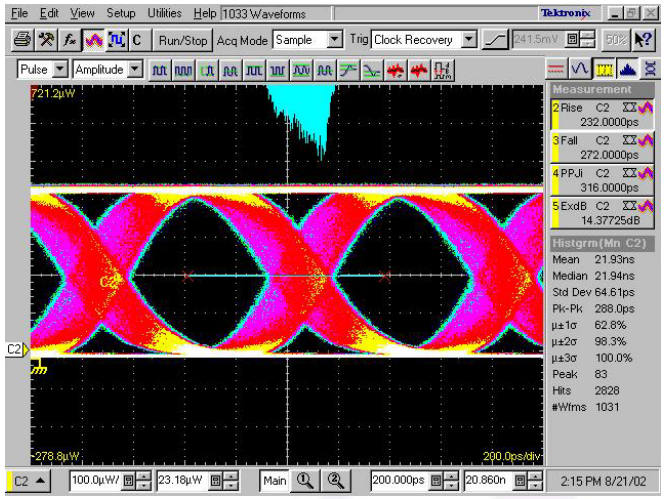


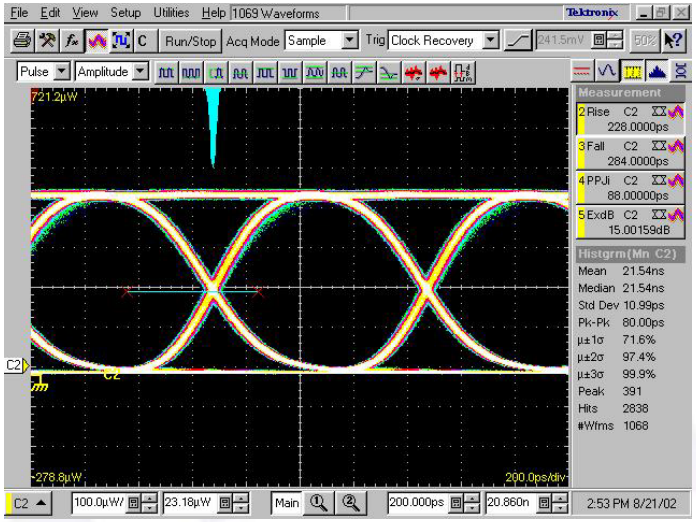
- GBIC with the same test setup.
- 100mV ripple introduced on VCC using a Bias-T.



System level Problems

Jitter transfer





- Ref Clock Jitter
  - Random Jitter = 11.19ps
  - Modulation = 100ps @ 350KHz
- Data Output (1.25Gbps)
  - Peak to Peak = 288ps
  - Standard Dev = 64ps

- Ref Clock Jitter
  - Random Jitter = 5.34ps
  - Modulation = Negligible
- Data Output (1.25Gbps)
  - Peak to Peak = 80ps
  - Standard Dev = 11ps

Setting the stage for 10 Gigabit

- Why
  - 10:1 backbone to desktop performance requirement
  - OC-192 overlap in metro and technology leverage
- Standardized Interfaces
  - Fiber MMF (850, 1310), SMF (1310, 1550)
  - Copper “in the works” CX4, 10GBase-T
- Issues
  - Cost (not 10x for 3x yet)
  - Dispersion limiting link length (not attenuation)

10 Gigabit Migration

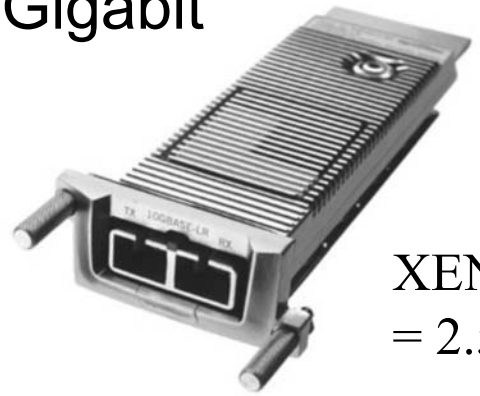
What can we learn from the past ?

1 Gigabit

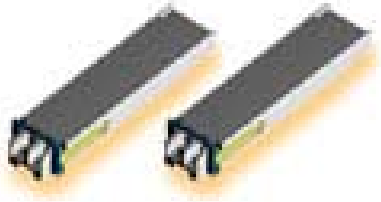
GBIC
= n mm^2

SFP
= 0.5n

10 Gigabit



XENPAK
= 2.5n



XFP
= 0.8n

Thank You !
Questions ?