10 Gb/s Serial PHY for Local Area Networks

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Thanks to: Jon Anderson, Mike Salzman, Paul Bonenfant, Enrique Hernandez-Valencia, Kamran Azadet, Paul Langner, Brian Ramelson

Wish List

- **Specify 10GMII to allow multiple PHYs (serial, parallel,..)**

- **Preserve simplicity and robustness of Ethernet PHY for LAN/MAN**

- **Scrambling to eliminate coding overhead for serial 10GE PHY**

- **Choose scrambler with good dc balance and robustness**

- **Carry 10G Ethernet within a WAN envelope when protection, restoration, and Operations, Administration, Maintenance (OAM) are required**
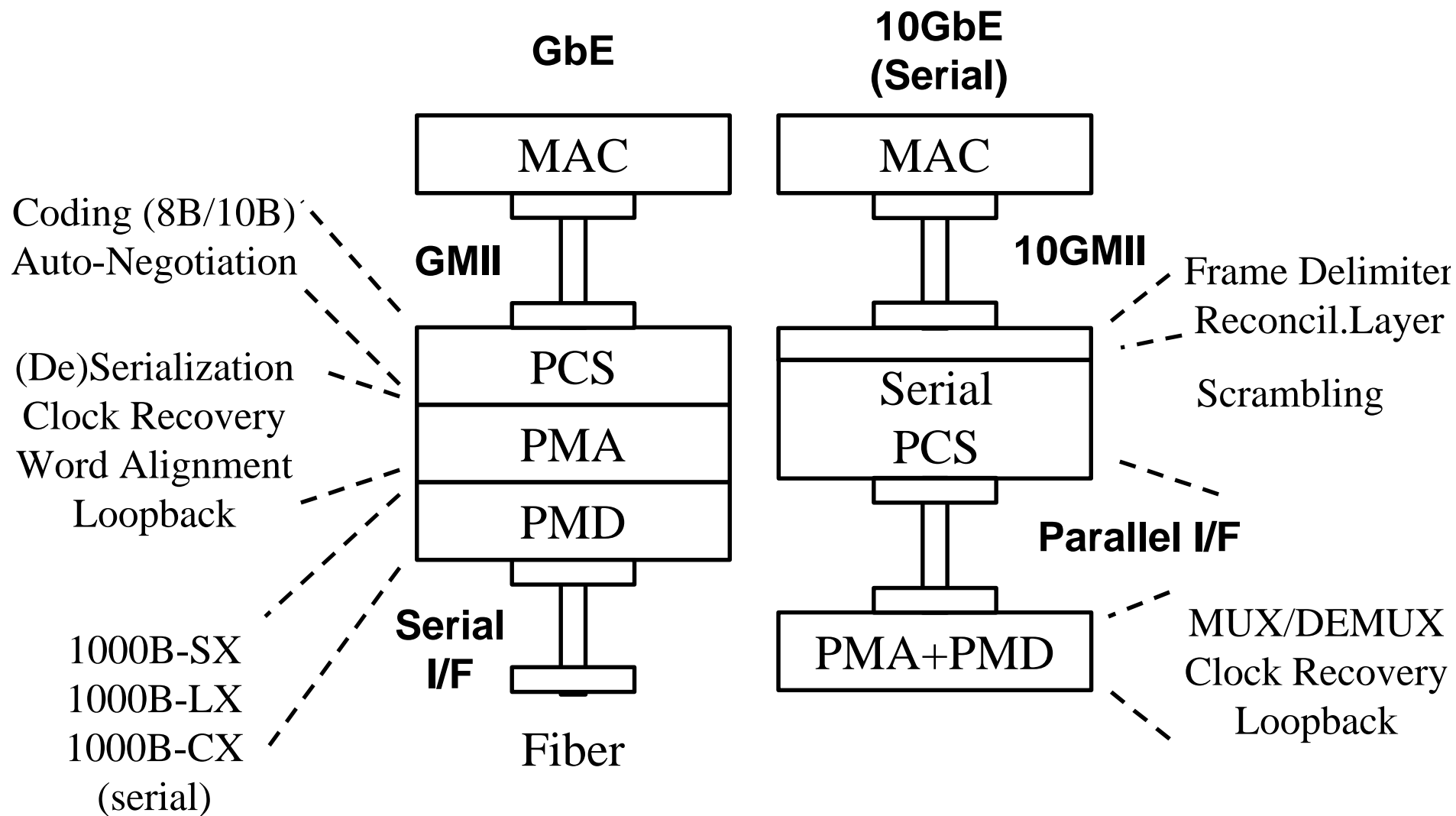
Why a Serial LAN PHY?

- **Moore's law (10x every 5 years) is on our side - assure longevity of standard**

- **new Silicon-based electronics technology will make 10Gb/s electronics cheap**

- **Many components vendors can do 10Gb/s optics and electronics now**

- **less failures with fewer lasers**

- **new MM-fiber supported by multiple vendors makes serial 300-m building riser link possible with multimode fiber**

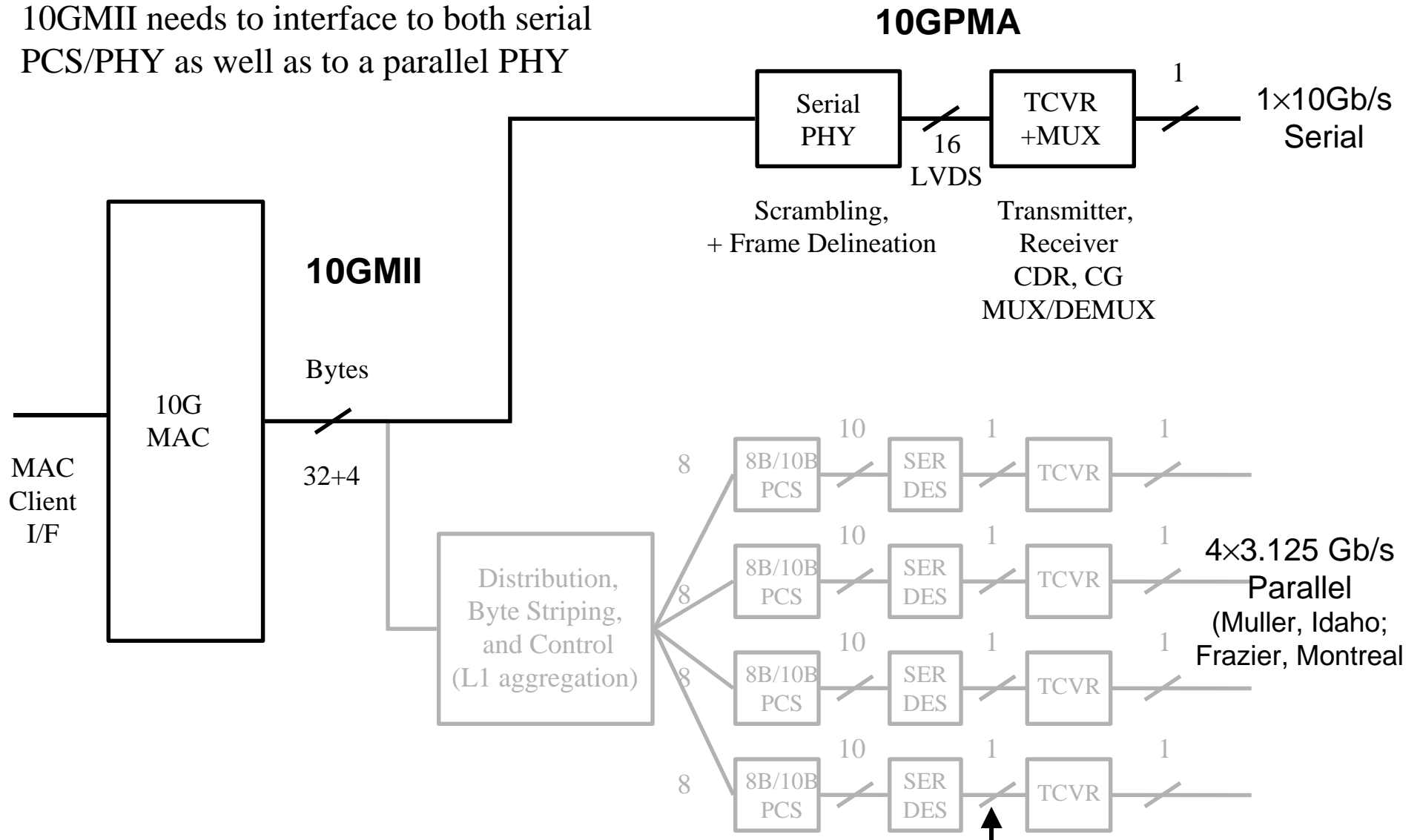- **Permits 10GE networking by DWDM or CWDM in the MAN/WAN**

Why Scrambling?

- **There is little reason to pay the 25% 8B10B overhead just for historical reasons**

- **8B10B coding has significant cost penalties for electronics and optics at 10 (12.5) Gb/s**

- **10 Gbaud is achieved routinely by many optics and electronics vendors; 12.5 Gbaud only by a few**

- **Lower line rate directly translates into longer distances supported in the LAN for both SM & MM fiber**

- **All the out-of-band signaling that 8B10B provides can be provided in-band with a scrambled code, with much less overhead**

- **Various frame/byte delineation techniques are known and have been implemented in silicon**

- **Scrambling is mature and well understood, and is easily implemented**

802.3 Reference Model

GbE

**10GbE
(Serial)**

Coding (8B/10B)
Auto-Negotiation

GMII

(De)Serialization
Clock Recovery
Word Alignment
Loopback

MAC

MAC

10GMII

Frame Delimiter
Reconcil.Layer

PCS

Serial
PCS

Scrambling

PMA

PMD

Parallel I/F

1000B-SX
1000B-LX
1000B-CX
(serial)

**Serial
I/F**

PMA+PMD

MUX/DEMUX
Clock Recovery
Loopback

Fiber

10GMII and PHY Layers

10GMII needs to interface to both serial
PCS/PHY as well as to a parallel PHY

10GPMA

| Serial PHY | /16 LVDS | TCVR +MUX | /1 | 1×10Gb/s Serial |

Scrambling,
+ Frame Delineation

Transmitter,
Receiver
CDR, CG
MUX/DEMUX

10GMII

| 10G MAC |

MAC Client I/F

Bytes

/ 32+4

Distribution,
Byte Striping,
and Control
(L1 aggregation)

8 → 10 → 8B/10B PCS → 1 → SER DES → 1 → TCVR → 1

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4×3.125 Gb/s
Parallel
(Muller, Idaho;
Frazier, Montreal

Frazier's "Serial Interface"

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PMD/PMA Physical Interface

Integrate MUX/DEMUX w/ 10G Optics to
isolate board designers from 10Gb/s signals

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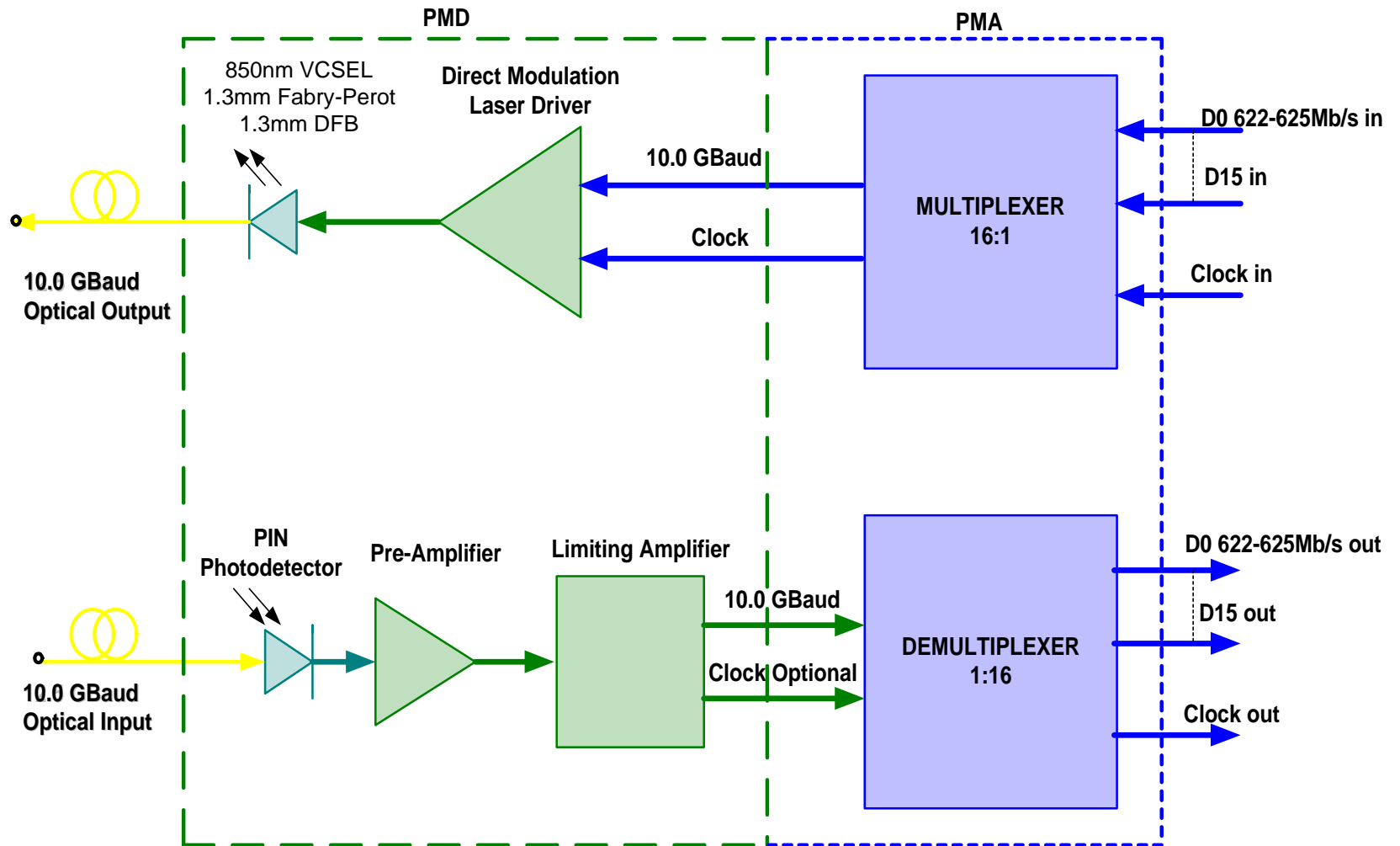
Discussion

- **32+4 bit 10GMII interface should be workable for both 10Gb/s serial and parallel (4x2.5 Gb/s) PHYs**

- **10GMII should allow attachment of parallel as well as serial PHY**

- **Howard Frazier's "serial" interface (4 x 2.5-3.125Gb/s) is not useful as attachment to a serial PHY because bytes are striped by that time to allow transmission over parallel link**

- **I am inviting contributions from both the serial as well as the parallel camp to come up with interfaces and PHY architectures that are workable for both, and don't favor one versus the other**
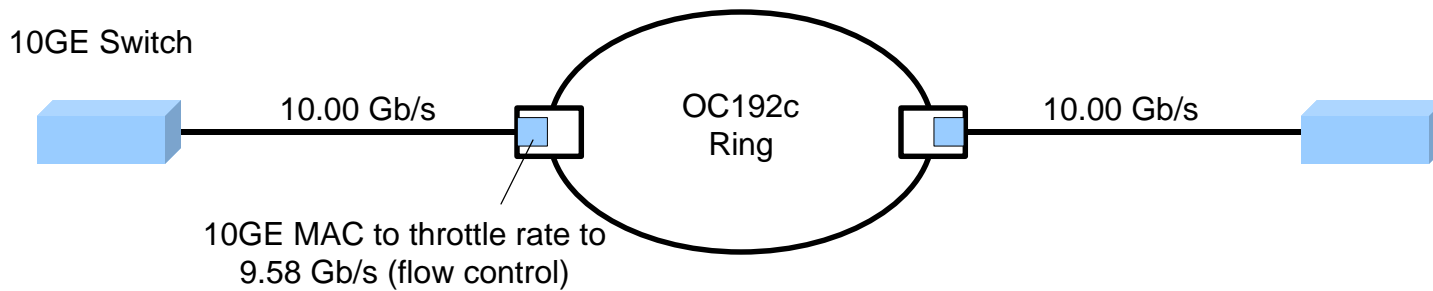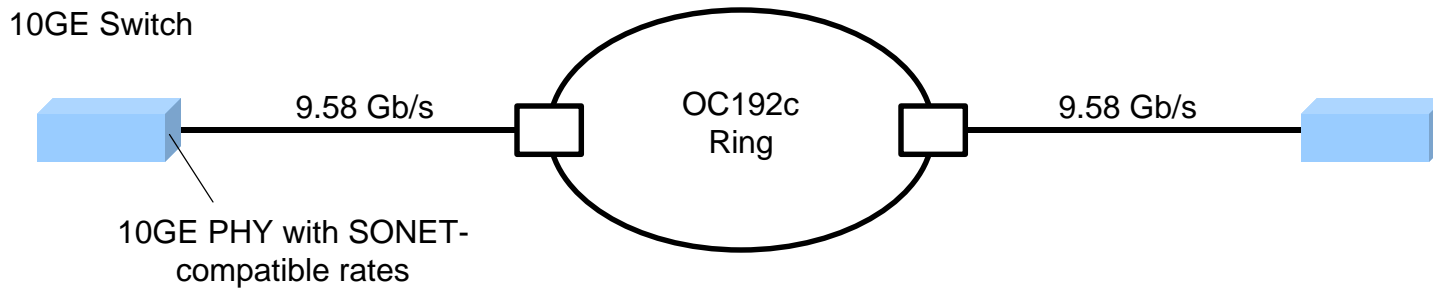
Scrambling Alternatives

- **ATM - like scrambler**
  - $x^{43}+1$ (self synchronous) from MAC DA through MAC FCS
  - x^7+x^6+1 (frame synchronous) over data including header
  - scrambler subject to malicious attacks
  - unscrambling required before header is read
- **SDL - like scrambler**
  - $x^{48}+ x^{28}\ x^{27}+x+1$ (periodically synchronized) from MAC DA through MAC FCS
  - does not propagate errors
  - no additional scrambling required over data+header
  - instead, 32-bit header XOR'd with maximum transition 0xB6AB31E0 to ensure DC balance
- **Frame Delimiter**
  - <length><CRC-16> delimiter less overhead than <length><type><CRC-16>
  - <length-0>: IFG; <length 1-63>: Control

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WAN Architectures

- **10GbE over Dark Fiber**
  - choice of exact data rate not important
  - scrambled coding has transmission advantage
  - new PHYs (10, 40, 80 km)

- **10GbE over WDM Optical Networks**
  - Optical Translation Units (OTU) are demarcation points into DWDM Optical Networks
  - short-reach (2km) SM-fiber interface, 9.95-10.00 Gbaud
  - Sometime FEC and baud rate >10 Gb/s used on DWDM side

- **10GbE over SONET/SDH**
  - requires 9.58 Gb/s data rate to be compatible with SONET/SDH interfaces and overhead
  - 9.95 Gb/s line rate
  - SR (2km) SM-fiber interface

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10GE over SONET Options

10GE Switch

9.58 Gb/s — OC192c Ring — 9.58 Gb/s

10GE PHY with SONET-compatible rates

10GE Switch

10.00 Gb/s — OC192c Ring — 10.00 Gb/s

10GE MAC to throttle rate to
9.58 Gb/s (flow control)

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10G Ethernet Considerations

- **Use scrambled serial PHY to assure widest support and availability of optics and electronics components**

- **Define 10GMII compatible with both serial and parallel PHY, and let technology and vendors compete for the market**

- **Don't burden 10GE LAN/MAN protocol with WAN OAM requirements**

- **To provide restoration, protection, and WAN OAM, wrap 10GE payload into WAN envelope**

- **SONET OC192c or emerging "over-optics" protocols are candidates to provide these WAN functions**

- **Specify WAN 10GE PHY that is compatible with such WAN protocols (to accelerate acceptance of 10GE in WAN)**

Thank You

1300nm Fabry-Perot Analysis over Standard Single Mode Fiber

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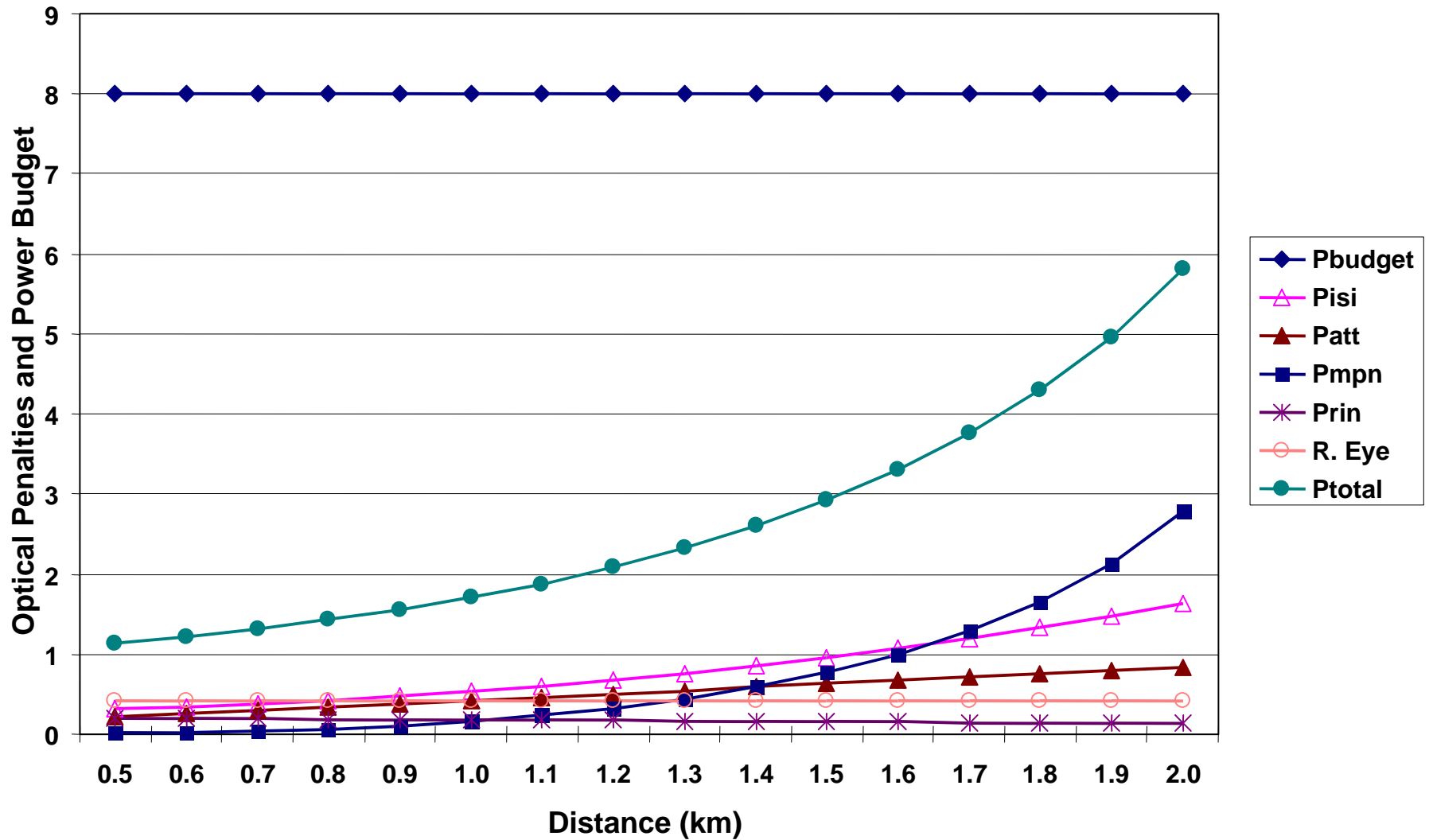
1300nm DFB Link Analysis over Standard Single Mode Fiber