Serial LAN PHY Proposal

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(Some endorsements added between March 1 and March 6.)

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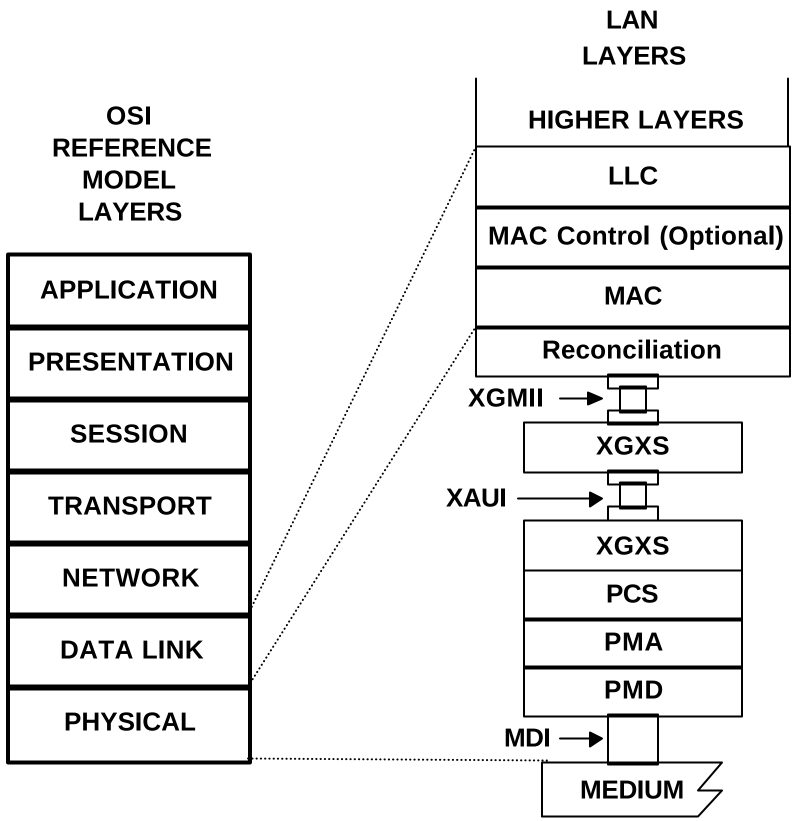
Purpose of this Presentation

- To introduce the concept of a complete Serial LAN PHY, from top to bottom
- To propose target specifications for Serial LAN PHY links

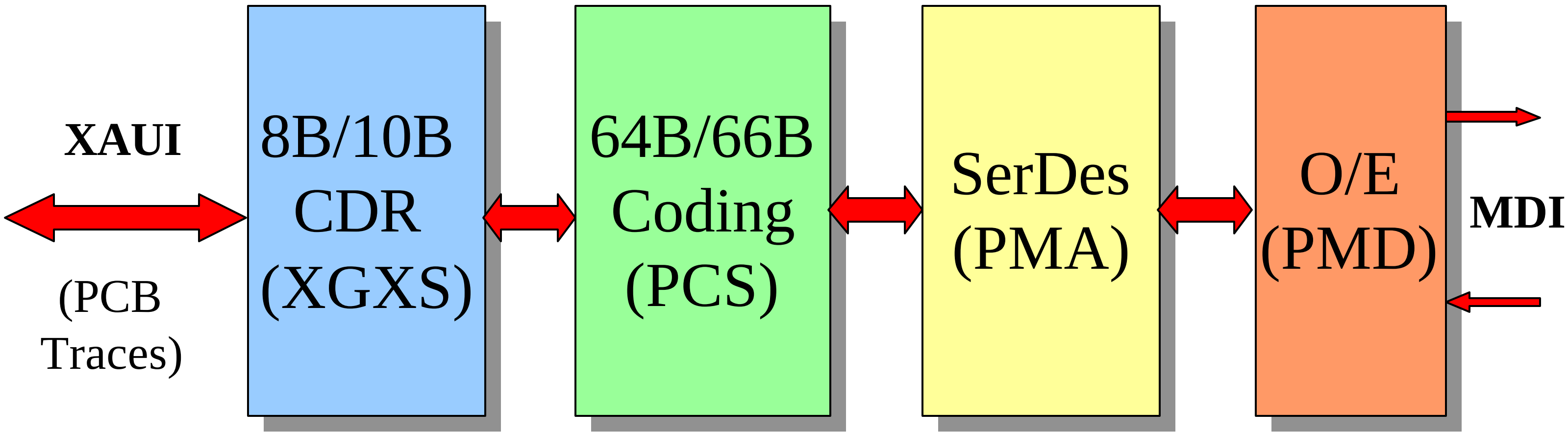
Layer Model



MDI = Medium Dependent Interface
XGMII = 10 Gigabit Media Independent Interface
XAUI = 10 Gigabit Attachment Unit Interface
PCS = Physical Coding Sublayer

XGXS = XGMII Extender Sublayer
PMA = Physical Medium Attachment
PHY = Physical Layer Device
PMD = Physical Medium Dependent

Implementation Example



XAUI/XGXS

- eXtended Attachment Unit Interface (XAUI)
- 10 Gigabit Extender Sublayer (XGXS)
- Convenient implementation partition, simplifies link development
  - Applicable to all proposed 10 GbE PHYs
- Extends XGMII to Serial PHY Transceiver module
- 3.125 Gbaud, 8B/10B encoded over FR-4 PCB traces
  - CDR-based parallel-serial self-timed interface replaces parallel bus
  - May be implemented in CMOS, BiCMOS, SiGe
- Directly maps XGMII data to/from PCS
- 36-bit word PCS Service Interface defined (XGXS ⇔ PCS)

Why 8B/10B? (for XAUI)

- Fast, robust synchronization
  - Unique comma character (K28.5) independent of data/phase
  - Simple implementation (2k gates for quad-SerDes)
  - Error detection (code violations)
- Well-controlled frequency spectrum
  - Run-length $\leq$ 5, DC-balance (Digital sum variation $\leq$ 6)
  - Capacitive coupling / level-shifting possible *on-chip*
  - PLL integration (loop filter, VCO phase noise, supply noise rejection, …)
- Compatible with other standards (InfiniBand™, Fibre Channel, …)
- Enables low cost, low power *ASIC* implementation

PCS

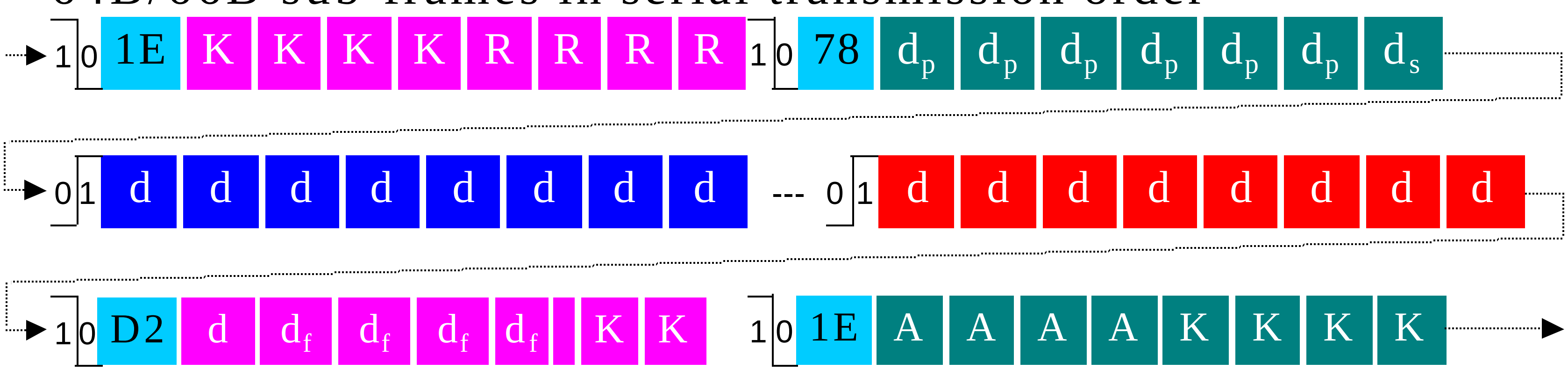
- Physical Coding Sublayer (PCS)
- Supports 10 Gbps data transport + high efficiency coding
- Directly maps XAUI/XGXS data to/from PMA
- Performs 64B/66B Encoding/Decoding
  - Statistically DC-balanced, high transition-density, quick-sync code
  - Frame and IPG control delineation preserved
  - Supports clock tolerance compensation functionality
- 66-bit word PMA Service Interface defined (PCS ↔ PMA)

XAUI/XGXS-to-PCS Mapping

XAUI/XGXS columns partitioned into 64B/66B sub-frames

Lane 0	K	R	S	d_p	d	d	---	d	d	d	d_f	A	K	R	K	R
Lane 1	K	R	d_p	d_p	d	d	---	d	d	d_f	T	A	K	R	K	R
Lane 2	K	R	d_p	d_p	d	d	---	d	d	d_f	K	A	K	R	K	R
Lane 3	K	R	d_p	d_s	d	d	---	d	d	d_f	K	A	K	R	K	R

64B/66B sub-frames in serial transmission order



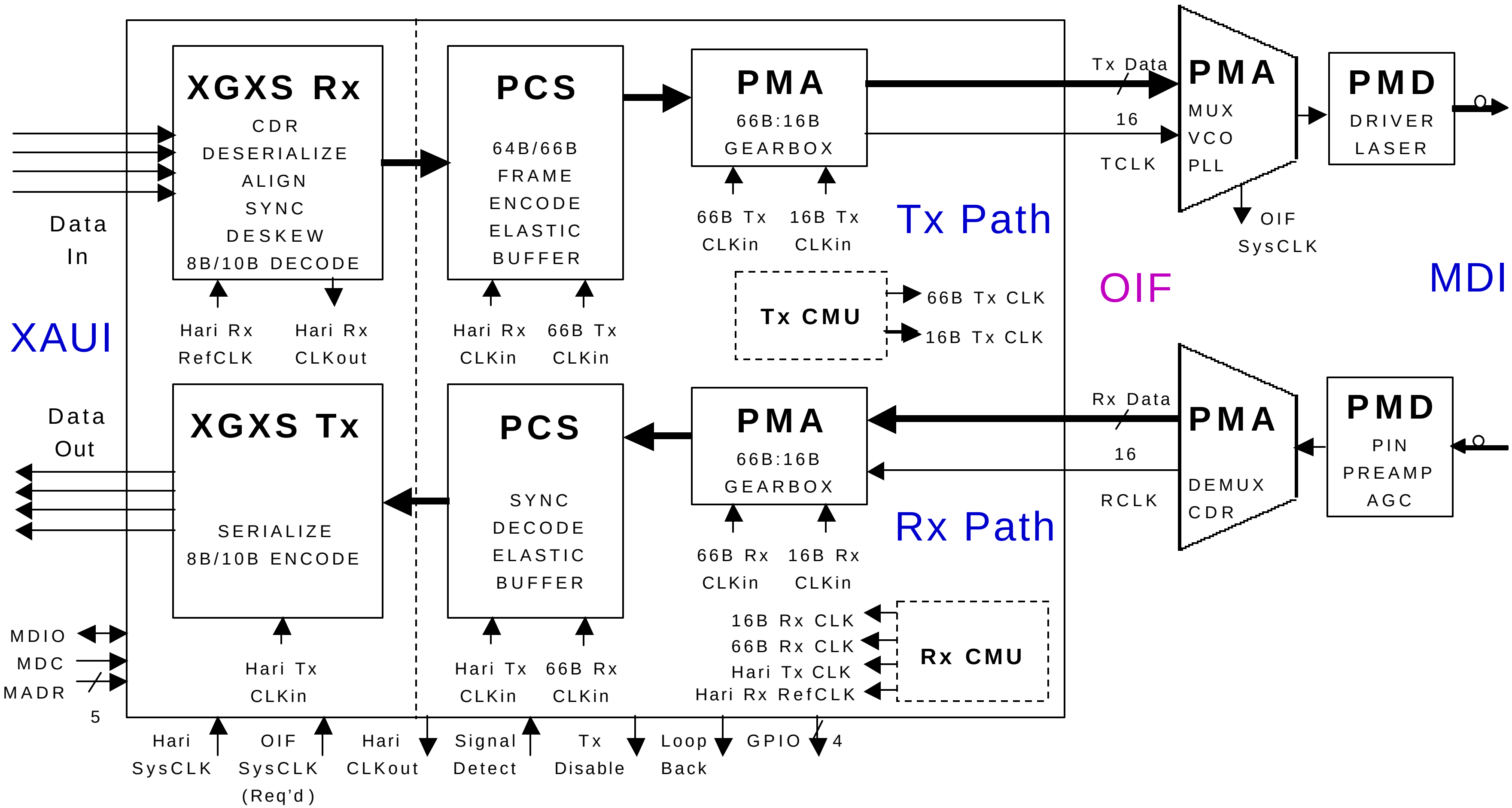
PMA

- Physical Medium Attachment (PMA)
- Directly maps PCS data to/from PMD
- Translates PCS 66B sub-frames to/from a PMD serial bit stream
- 1-bit PMD Service Interface defined (PMA ↔ PMD)
- Intra-PMA physical interfaces not specified (I.e. may be 16b, 4b, etc.)
- Serializer, Deserializer and Clock/Data Recovery unit specified
- PCS clocks Tx data to PMA, PMA clocks Rx data to PCS
  - PMA based reference clock provides PCS/PMA master clock

Why 64B/66B?

- Provide full 10.000 Gb/s bandwidth for LAN applications
  - No flow-control necessary for LAN applications
  - Extends LAN to 40km+ applications
- Interface directly to XAUI with control code transparency
  - Allows interoperability with other common backplane coding schemes (Fibre Channel, InfiniBand™ as well as XAUI)
- Ensure statistical DC-balance, transition density, and frame synchronization properties suitable for optical transmission
  - Two-bit preamble allows frame synchronization AND sets maximum degenerate run length at 66 bits
  - May be implemented in <5k gates.
  - 4-bit Hamming protection over packet, data, and control
- Low overhead allows compatibility with existing SONET optical transceivers

Implementation Example



PMD - Five Candidates

1. 300 m., 850 nm, VCSEL, new multimode
2. 2 km, 1310 nm, FP laser, singlemode
3. 10 km, 1310 nm, DFB or VCSEL, singlemode
4. 40 km, 1310 nm, DFB, cooled, singlemode
5. 40 km, 1550 nm, DFB, singlemode*

* A suitable method of specifying the required cable plant quality is under consideration.

Link Model

- Original: “for802_3ae05.xls”, by Hanson, Cunningham, Dawe.
- Modified by Vipul Bhatt and Piers Dawe into two files:
  - “for802_3ae07_LAN_RevB2.xls”, and
  - “for802_3ae07_WAN_RevB2.xls”.
- Target Specifications are still under review and will be refined further.

Link Power Budget & Penalties

Description	Type 1	Type 2	Type 3	Type 4	Type 5	Unit
Fiber type	New MMF	SMF	SMF	SMF	SMF	-
Wavelength (range)	840 to 860	1290 to 1330	1290 to 1325	1300 to 1315	1530 to 1560	nm
Link power budget	8.00	10.84	10.84	26.84	20.84	dB
Operating distance	300	2000	10000	40000	40000	m
Channel insertion loss	2.59	3.01	7.04	21.98	13.82	dB
Link power penalties	3.61	6.15	2.30	3.02	4.27	dB
Unallocated margin in link power budget	1.80	1.68	1.50	1.84	2.76	dB

Note: Baseline wander is measured in terms of the standard deviation of the distribution, then normalized to ½ of the vertical eye opening at TP4. It is assumed to be 2.5%.

Transmit Characteristics

Description	Type 1	Type 2	Type 3	Type 4	Type 5	Unit
Tx type	SW laser	LW laser	LW laser	LW laser	LW laser	
Signaling Speed (range)	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	GBd
Wavelength (range)	840 to 860	1290 to 1330	1290 to 1325	1300 to 1315	1530 to 1560	nm
Trise/Tfall (20%-80%)	30	40	40	40	20	ps
RMS Spectral Width (max)	0.20***	2.75*	0.40	0.20	0.05	nm
SMSR	-	-	30	30	30	dB
Avg. launch power (max)	-1.3	+2	+2	+7	+2	dBm

Tx Characteristics (cont'd)

Avg. launch power (min)	-5.5	-4	-4	+4	-2	dBm
Avg. launch power of OFF transmitter (max)	-30	-30	-30	-30	-30	dBm
Extinction Ratio** (min)	7	6	6	6	6	dB
RIN (max)	-125	-130	-130	-130	-140	dB/Hz

*Requires k factor 0.5 max.

** Alternate, OMA-like representation is under review

***Under review. Some experimental evidence suggests that a much larger linewidth may be specified.

Receive Characteristics

Description	Type 1	Type 2	Type 3	Type 4	Type 5	Unit
Signaling speed (range)	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	10.3125 +/- 100 ppm	GBd
Wavelength (range)	840 to 860	1290 to 1330	1290 to 1325	1295 to 1315	1530 to 1560	nm
Avg. receive power (max)	-1.3	+2	+2	TBD	+2	dBm
Receive sensitivity	-13.5	-14.84	-14.84	-22.84	-22.84	dBm
Return loss (min)	12	12	12	12	12	dB
Stressed receive sensitivity	-8.52	-7.44	-11.47	-18.41	-16.25	dBm
Vertical eye closure penalty	TBD	TBD	TBD	TBD	TBD	dB
Receive electrical 3 dB upper cutoff frequency (max)	12.36	12.36	12.36	12.36	12.36	GHz

Further Work

- Define Jitter specifications
- Improve MPN model
- Consolidate some link types
- Validate link model with experiments
- Study dynamic range vs. sensitivity tradeoffs
- Research better ways of specifying cable plant quality