IEEE 802.3ae Task Force

MultiLevel MultiChannel PMD Proposal

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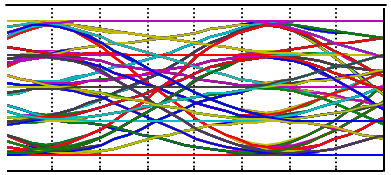
Why MultiLevel and MultiChannel?

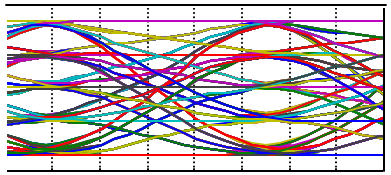
- These technologies likely to be combined in the future
  - To increase data rates beyond 10 Gbps
- MAS and WWDM each push technology limits
  - MAS: 5 Gbaud O/E, Linear TIAs
  - WWDM: Class 1 Laser safety limits, quad O/E set & mux/demux
- Alternative: Leverage BOTH PMD technologies now
  - Conceptually similar to 10000BASE-T proposal
  - Support low-cost 850 nm VCSELs again
  - Reduce WWDM O/E parts/power via integration & 2WDM
  - Longer MMF distances @ 2.5 Gbaud than WWDM or MAS
  - Leverage Hari jitter control, smart link protocol to ease link design
  - Scalable to higher speeds (e.g. 40 Gbps, etc.)

MAS PMD Technology



- NRZ, Quinary Amplitude Shift Keying of Optical Intensity
  - A.k.a. 5-level PAM of Optical Intensity
- 5 Gbaud (2.5 GHz) line rate for 10 Gbps
- Simple Single-Channel (Serial) PMD type
- Adaptation of 1000BASE-T Ethernet modulation, but simpler
  - No crosstalk, echo, DSP FEC compensation required
- PMD independent: Optical LW/SW, MMF/SMF, CX Copper
- Hari/MAS/laser driver implementable in ≤0.18µm CMOS
  - Single CMOS chip includes Laser Driver for most PMDs
  - Only Laser, PIN, and TIA required for full PMD
  - Small, Low Power, accommodates Small Form Factor package
  - 10G PMD BOM should be not much higher than for 1G at maturity
- Closed-Loop feedback optimizes Tx/Rx link operation

MAS/2WDM PMD



- NRZ, Quinary Amplitude Shift Keying of Optical Intensity
  - A.k.a. 5-level PAM of Optical Intensity
- 2 x 2.5 Gbaud (1.25 GHz) line rate for 10 Gbps
- Two-Channel WDM PMD type
- Adaptation of 1000BASE-T Ethernet modulation, but simpler
  - No crosstalk, echo, DSP FEC compensation required
- PMD independent: Optical LW/SW, MMF/SMF, CX Copper
- Hari/MAS/2WDM implementable in ≤0.18µm CMOS
  - Single CMOS chip includes Laser Drivers for most PMDs
  - CMOS chip can include TIA and limiting Post-Amps
  - Only Laser, PIN required for full PMD
  - Small, Low Power, accommodates Small Form Factor package
- Closed-Loop feedback optimizes Tx/Rx link operation

PAM5×4/2WDM Attributes

- Meets or exceeds ALL HSSG distance objectives
  - 2.5 Gbaud line rate yields ~400 m over installed MMF @ 1300 nm
  - ~125 m over installed MMF @ 850 nm (160 MHz-km)
  - ~1.6 km over enhanced MMF @ 850 nm
  - 2/10/40 km SMF OK. Need HD Laser Driver for >10 km
- ↓ rate = ↓$ O/E, ↑ distance, ↑ reliability, ↓ emissions
- ↓ costs with CMOS, smart closed-loop optical feedback
- Open technology, no basic IP, no barriers to entry
- Higher rates with more sophisticated modulation
  - E.g. PAM9, QAM, FDM), mode WDM λ, Parallel Optics
- 1/10 GbE operation: 1GbE on one λ and half-speed
- Risks: New technology for optics, Need Linear TIA

PAM5×4/2WDM Mapping Example

Parallel 10GMII (Sali) - 36 bits @ 156.25 MHz DDR - 10 Gbps

D<0:7>	I	I	S	d_p	d	d	---	d	d	d	d_f	I	I	I	I	I
D<8:15>	I	I	d_p	d_p	d	d	---	d	d	d_f	T	I	I	I	I	I
D<16:23>	I	I	d_p	d_p	d	d	---	d	d	d_f	I	I	I	I	I	I
D<24:31>	I	I	d_p	d_s	d	d	---	d	d	d_f	I	I	I	I	I	I

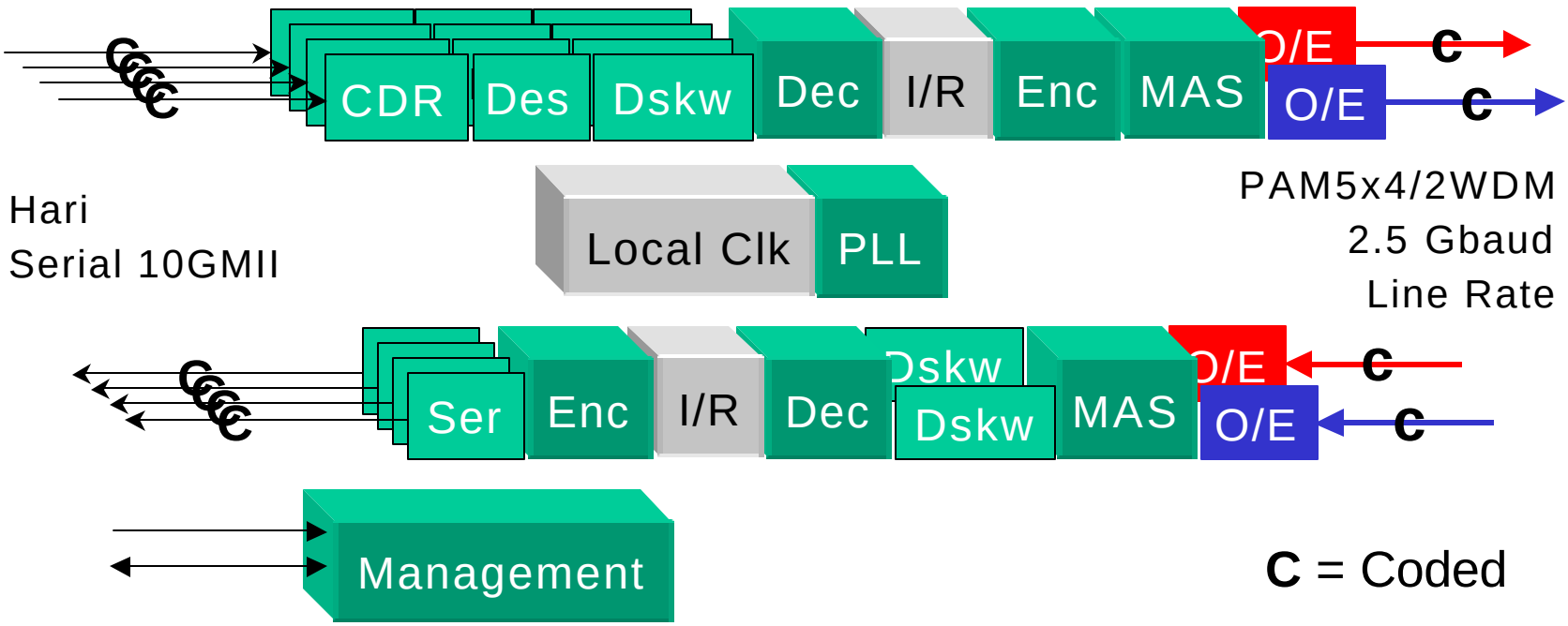
Serial 10GMII (Hari) - 4 lanes @ 3.125 GHz - 10 Gbps

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

PAM5´4/2WDM - 2 channels @ 2.5 Gbaud, 2 bits/baud - 10 Gbps

Channel 0	R	S	d_p	d_p	---	d	d	d	---	d	d_f	d_f	K	A	A	K
Channel 1	R	d_p	d_p	d_p	---	d	d	d	---	d_f	d_f	T	K	A	A	K

PAM5×4/2WDM PMD Data Flow



- Hari compatible, Connectorizable, Pluggable
- Optics independent. Supports 1300 nm and 850 nm lasers

10 GbE MAS Specific Elements