Investigation Topics

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Introduction to Revised Presentation

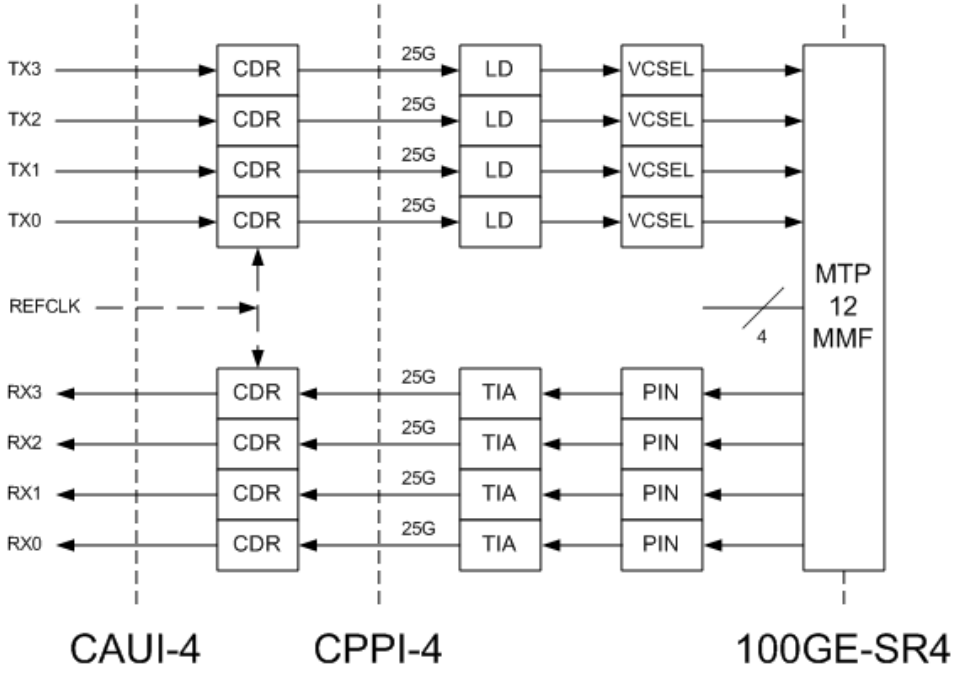
- cole_01_0911 was presented during the Next Generation 100G Study Group meeting on 9/14/11
- The designation “2km dedicated optics” and recommendation to not investigate PMD alternatives for this dedicated application was confusing to a number of the meeting participants
- Specifically the intended message that the designation referred to telecom central office 2km optics as specified in the ITU-T or IEEE was lost, and the recommendation was interpreted as excluding 2km reach from consideration for any new PMD
- To clarify, cole_01_0911 is revised to create cole_02_0911 by changing the designation to “2km telecom optics”, refining the definition of the designation throughout the presentation, and removing the associated recommendation
- It was also pointed out that “1000m structured IDC optics”, as designated in cole_01_0911, can support applications below 300m, so to not imply a limit on the application space the designation in cole_02_0911 is changed to “1000m structured data center optics”

Existing and Next Gen 100G Optics

Optics designation	100m	1000m	2km to 10km
primary application	high density data center	structured data center	telecom & general data center
~loss budget	2dB	2.5dB	6dB*
~link budget = loss + penalties	8dB	3dB	8.5dB
bit/sec cost & power target	~10GE-SR	~10GE-SR	~10GE-LR
volume laser technology	VCSEL PIC	TBD	DFB PIC
fiber	parallel MMF	duplex SMF	duplex SMF
Existing standard	100GE-SR10	none	100GE-LR4
Next Gen standard	100GE-SR4	100GE-nR4 ???	none

* 2km telecom optics min loss budget is 4dB

100m High Density Optics



- **100m high density optics should be a NG 100G SG investigation**
- Investigation should include determining the best 4x25G electrical I/O:
  - CAUI-4; w/ & w/o FEC
  - CPPI-4; w/ & w/o FEC, w/ & w/o EDC
- Exact reach TBD

1000m Structured Data Center Optics

- Majority of 10G data center interfaces are 10GE-SR
- 10GE-SR VCSEL technology has significantly lower cost & power than 10GE-LR DFB laser technology
- 10GE-SR 300m reach covered 99% of data center links when adopted in 2002, and still covers majority of links today
- Since 2002, the appearance of Internet Data Centers (IDCs) with link reach requirements >300m created a new application:

  10G structured link reach < 1000m @ ~10GE-SR bit/sec cost
- Similar link applications exist or will exist at 40G and 100G
- 100GE-SR10 and 100GE-SR4, using parallel VCSEL Array and MTP connector technology, are not practical for >300m link applications
- 100GE-LR4, using DFB PIC technology, exceeds 10GE-SR bit/sec cost & power
- Large difference between 1000m structured and 10km general optics link budgets (>6dB) offers opportunities for new technologies

1000m Structured Data Center Optics

- **1000m structured IDC optics should be a NG 100G SG investigation**
- Optics technologies TBD
  - 100GE-LR4 WDM cooled 4x25G DFB PIC (reference baseline)
  - un-cooled CWDM DFB PIC (unlikely to be compelling)
  - Si modulator PIC
  - InP modulator PIC
  - Long Wave VCSEL PIC
  - others
- Market potential and volume timeline TBD
- Exact reach TBD
- **Caution:** No justification may be found in NG 100G SG for 1000m duplex SMF optics standard, either because of insufficient market volume or immature optics technology

2km Telecom Optics

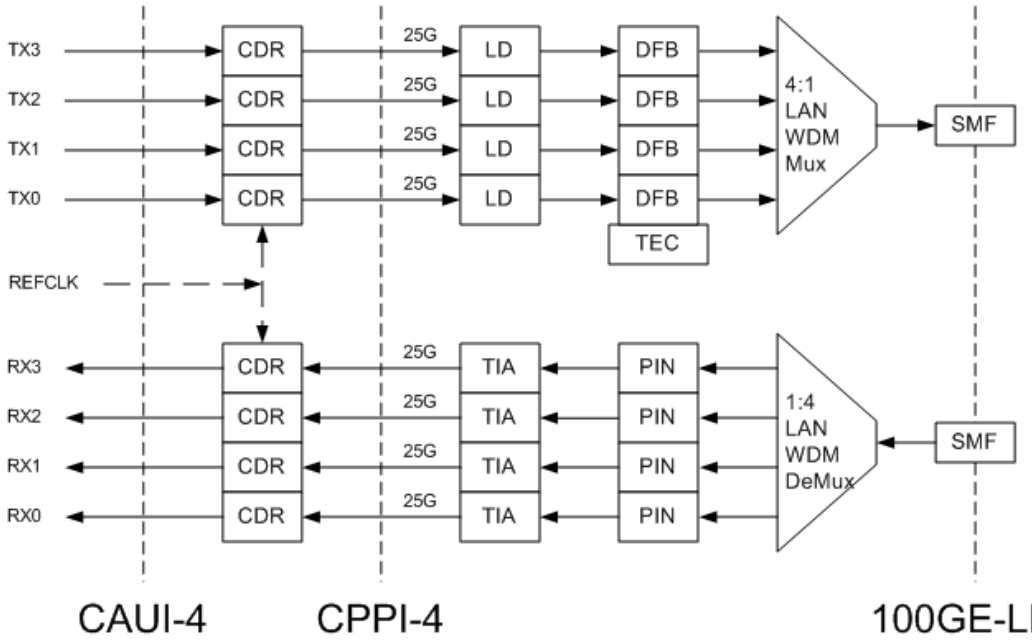
40G 2km telecom optics link budget	ATT	China Telecom	Deutsche Telekom	NTT	Sprint	Verizon
6dB deployed (4dB loss budget)	Yes	Yes	Yes	Yes	Yes	Yes
7dB preferable (5dB loss budget)	Yes	Yes	Yes	Yes	Yes	Yes
4dB sufficient for all links	No	No	No	No	No	No

- Source: “100Gb/s SMF Client Reach Specs” presentation during NG Optical PMD CFI Discussion, 11/8/10, Dallas, TX
- All deployed 10G & 40G 2km telecom optics have 4dB min loss budget
- 100G 2km telecom optics application is the same as 40G application
- 100G 2km telecom optics cost target: ~10GE-LR bit/sec

2km Telecom Optics

- 10GE-LR 10km general data center optics have 6.2dB min loss budget (9.4 link budget)
- OC-192 SR-1 2km telecom central office optics have 4dB min loss budget (5dB link budget)
- Volume of the two 10G applications is similar
- Early SR-1 single rate 300-pin modules have been replaced by pluggable dual rate modules which meet both specifications
- Despite large link budget difference, lower cost of 2km telecom optics does not justify dedicated SR-1 single rate 10G pluggable modules
- 40G is the same; LR4 WDM tri-rate modules are the lowest cost solution for 40GE, STM-256 and OTU3 client applications
- 100G is also the same; LR4 WDM dual-rate modules will be the lowest cost solution for 100GE and OTU4 client applications
- Split in volume and extra OpEx cost of supporting two different SMF interface types wipes any out cost savings of dedicated 2km modules

10km General Data Center Optics



- **100GE-LR4 will be the lowest cost 2km telecom and 10km general data center optics solution**
- NG 100G SG investigation should determine best 4x25G electrical I/O to support 100GE-LR4 optics:
  - CAUI-4; w/ & w/o FEC
  - CPPI-4; w/ & w/o FEC, w/ & w/o EDC

Next Gen 100G Optics Scenario Example

Electrical I/O type	MMF	SMF
Baseline	100GE-SR4	100GE-LR4
Extended (ex. w/ FEC)	100GE-SR4+	100GE-LR4 reduced cost

- Baseline I/O (ex. CAUI-4) supports standard specifications
- Extended I/O (ex. FEC) can be used to:
  - extend electrical and optical performance
  - reduce cost through simplified design and testing (ex. no low BER specifications and measurements)
- Auto Negotiation can be used to revert to baseline performance

Recommendations

- The following are recommended for NG 100G SG optical investigation:
  - 100m high density data center optics, including exact reach
  - 1000m structured data center optics, including exact reach
- The following are recommended for NG 100G SG electrical investigation:
  - CAUI-4; w/ & w/o FEC
  - CPPI-4; w/ & w/o FEC, w/ & w/o EDC