What's so special about 10km?

P802.3cu 100 Gb/s and 400 Gb/s over SMF
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FINISAR

10G, 40G & 100G Reach Summary

Reach, km			0.5	2	10	20	30	40	80
10G	Data-com	code			LR			ER	ZR
		loss, dB			6.2			11	22
	Tele-com	code	G.693	G.693		G.959.1		G.959.1	G.959.1
		loss, dB	4	4		6		11	22
40G	Data-com	code		FR	LR4		ER4	ER4	
		loss, dB		4	6.7		16.5	18.5	
	Tele-com	code		G.693	G.695			G.695	G.695
		loss, dB		4	6.7			14.5,18.5	22.5
100G	Data-com	code	PSM4, OCP	CWDM4	LR4, 4WDM	4WDM	ER4	ER4, 4WDM	
		loss, dB	3.3, 3.5	4 + 1	6.3, 6.5	10.2	15	18	
	Tele-com	code		G.695	G.959.1			G.959.1	
		loss, dB		4 + 1	6.3			18	

loss in black: O-band, loss in red: C-band, 10G G.693 reach = 600m

50G, 200G & 400G Reach Summary

Reach, km			0.5	2	10	20	30	40
50G	Data-com	code		FR	LR			
		loss, dB		4	6.3			
	Tele-com	code						
		loss, dB						
200G	Data-com	code	DR4	FR4	LR4			
		loss, dB	3	4	6.3			
	Tele-com	code						
		loss, dB						
400G	Data-com	code	DR4, *100G DR*	FR8, “FR4”	LR8, “LR4”			
		loss, dB	3, 3	4, 4	6.3, 6.3			
	Tele-com	code						
		loss, dB						

loss in black: O-band, 400G LR8 uses 0.46dB/km

10G Reach Break Points

Reach	*2*	10	40	80	unit
Code	*n/a*	LR	ER	ZR	
λ	*1310*	1310	1550	1550	nm
Loss		6.2	11	22	dB
TX	*DML*	DML	EML	EML	
RX	*PIN*	PIN	PIN	APD	

- 802.3ae decided that there was no benefit to a separate 2km code; yield to 10km spec. was judged similar to 2km spec
- Telecom 2km SR-1 (G.693) 4dB loss dual-mode optics got a free 6dB

≤ 2km Reaches Observations

- Traditional indoor reach, supporting worst case intra-building, multi-floor links
- Cloud datacenter reach requirements first identified by Donn Lee, Google, March 2007 HSSG meeting:
  - 400m to 1km
- 1310nm SMF penalties and loss are minor and similar for various < 2km reaches; 500m, 600m, 1km, 2km
- Penalties dominated by TX into ref. RX
- Link budget dominated by passive component loss including connectors, patch panels, and optical switches
- Link budget range: 5dB → 8dB

> 2km Reaches Observations

- 802.3 HSSG extensively studied data center link reach over 16 month period, with main effort by HSSG Reach Ad Hoc
- HSSG study results based on responses from datacenter operators (see 802.3ba email archives) found:
  - distribution of SMF reaches between 500m to 10km
  - ≤ 4km reaches with 10km loss budget
- Inter-datacenter reaches vary from 2km to 100km, with tail-off above 20km. Exact distribution varies in different studies
- Nobody sites datacenters to land on a round number reach
- 10km link budget range: 9dB ± ½ dB
- 40km link budget: ~18dB (1310nm)
- 40km is not a good break point for ≥ 25Gbaud or higher; 20km to 30km makes better sense
- ≥ 40km (i.e. 80km) for >10G rates: requires DWDM optics

Conclusions

- Each rate has it's own technology break points.
- Using the 10km, 40km, 80km breakpoints from 10G, for higher rates, places artificial constraints on optics specifications. The true cost of these artificial constraints is not made sufficiently visible to the end user
- Example of break-points for 50GBaud technology
  - 2km (not necessary to differentiate 500m, 1km and 2km)
  - < 10km, ex. 8km
  - 20km or 25km
  - > 25km: Coherent
- Basing optical specifications on numerology, i.e. attributing mystical properties to round numbers is not good engineering

Proposal

- Consider associating break points with established loss budgets, rather than reaches

	DRn	FRn	LRn	XXn	ERn	unit
Loss	3	4	6.3	11	18	dB
Reach	~0.5	≤ 2	≤ 10	≤ 20	≤ 40	km

- The exact reach is chosen for optimum technology break point to optimize cost vs. penalties
- The loss is not recalculated and reduced even if reach is lowered as per above, as that's what the users expect

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Thank You