10/10 and 10/1 budgets

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10 Gb/s components

- NOTE: All values here are specified in OMA
  - Sensitivity is measured with the 'worst transmitter and longest/worst link'
  - Believed to be equivalent to 'stressed sensitivity'
- 10 Gb/s receivers (CW mode)
  - PIN-based: OMA sensitivity around -14 ~ -16 dBm
  - APD-based: OMA sensitivity around -22 dBm
- FEC
  - A target for FEC optical gain: 4 dB
- So, with FEC, the receivers can give us
  - PIN-based: sensitivity around -18 ~ -20 dBm
  - APD-based: sensitivity around -26 dBm

Av. Power to OMA conversion

- At ER =infinity: OMA = Power + 3dB
- At ER = 10 db: OMA = Power + 2.14
- At ER =   9 dB: OMA = Power + 1.91 <<<
- At ER =   6 dB: OMA = Power + 0.78 <<<
- At ER=4.76dB: OMA = Power

Budget, Loss, and Penalties

- Here, we use the following definition:
  - Budget = Max. Loss = Tx(min) – Sensitivity(stressed)
- Note: Since ‘sensitivity’ includes optical path, no separate optical path penalty is needed
- Straw polls indicated an interest in defining three budgets:
  - “PX10” : 20 dB loss (an approximate value)
  - “PX20” : 24 dB loss (an approximate value)
  - “B++” : 29 dB loss
- Let’s assume a dynamic loss range of 15 dB

Our single data point

- The 1GE-PON OLT OMA sensitivity is -27.6 dBm (‘stressed sensitivity’)
  - The following slide shows a best-effort at trying to reconstruct the whole budget(!)
- From the dual-rate burst mode analysis
  - Simple ‘parallel’ receiver will have a sensitivity delta of ~7 dB between 1.25G and 10G
- So, 10G sensitivity of -20.6 dBm should be possible
  - Let’s round it down to -20 dBm
  - With FEC, that gives us -24 dBm

Upstream 1G Budgets (no FEC)

(dBm)	PX10	PX20	B++
OLT Rx OMA Stressed sensitivity	-21.5	-23.6	-27.6
FEC Gn (dB)	0	0	0
Budget (dB)	21.3	23.4	29
ONT Tx Min OMA (dB)	-0.2	-0.2	1.4
ONT Tx Min Power	-1	-1	-1
ONT Tx Max Power	+4	+4	+5
OLT Rx Ovr	-3	-3	-9

Upstream 10G Budgets

(dBm)	PX10	PX20	B++(a)	B++(b)
OLT Rx OMA Stressed sensitivity	-20.6	-20.6	-20.6	-25.6
FEC Gn (dB)	0	4	4	4
Budget (dB)	20	24	29	29
ONT Tx OMA Min (dB)	-0.6	-0.6	4.6	-0.6
ONT Tx Min Power	-2	-2	+3	-2
ONT Tx Power Max	+4	+4	+9	+4
OLT Rx Ovr	-1	-1	-1	-11

Downstream 10G Budgets

(dBm)	PX10	PX20	B++(1)	B++(2)
ONU Rx OMA Stressed sensitivity	-16	-16	-16	-21
FEC Gn (dB)	0	4	4	4
Budget (dB)	20	24	29	29
ONT Tx OMA Min (dB)	4	4	9	4
OLT Tx Min	+2	+2	+7	+2
OLT Tx Max	+7	+7	+12	+7
ONT Rx Ovr	+2	+2	+2	-3

Important simplifications

- The design approach was to reduce the number of distinct optic types
- PX10 and PX20 PMD are identical
  - We use FEC to take the PX10 budget the extra 4 dB to reach the PX20 budget
- B++ budget defines only 1 new optic
  - We improve only one side to get the 5 dB to reach the B++ budget
- Other approaches are possible, but
  - It is unclear if they reduce device and system cost significantly
  - They will certainly result in more optic types, and this could reduce volumes and cause uncertainty in the market

The big B++ questions

- Upstream
  - Option a: APD at OLT (receiver constant)
    - Keeps OLT constant across all classes
    - Requires a High power ONT for B++
  - Option b: Pre-amplified OLT (transmitter constant)
    - Keeps ONT constant across all classes
    - Requires a Super sensitive OLT for B++
- Downstream
  - Option 1: PIN at ONT (receiver constant)
    - Keeps ONT constant across all classes
    - Requires a High power OLT for B++
  - Option 2: APD at ONT (transmitter constant)
    - Keeps OLT constant across all classes
    - Requires a Super sensitive ONT for B++

Possible Choices

Downstream

Upstream

	PIN at ONT (Option 1)	APD at ONT (Option 2)
APD at OLT (Option a)	1a: Both Rx constant Symmetric system: 2 ONT, 2 OLT Asymmetric system: 1 ONT, 3 OLT	2a: OLT Constant (kinda) Symmetric system: 2 ONT, 1 OLT Asymmetric system: 2 ONT, 3 OLT
SOA at OLT (Option b)	1b: ONT constant Symmetric system: 1 ONT, 2 OLT Asymmetric system: 1 ONT, 3 OLT	2b: Both Tx constant Symmetric system: 2 ONT, 2 OLT Asymmetric system: 2 ONT, 3 OLT