Enhanced FEC enables low-cost 25G EPON

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Introduction

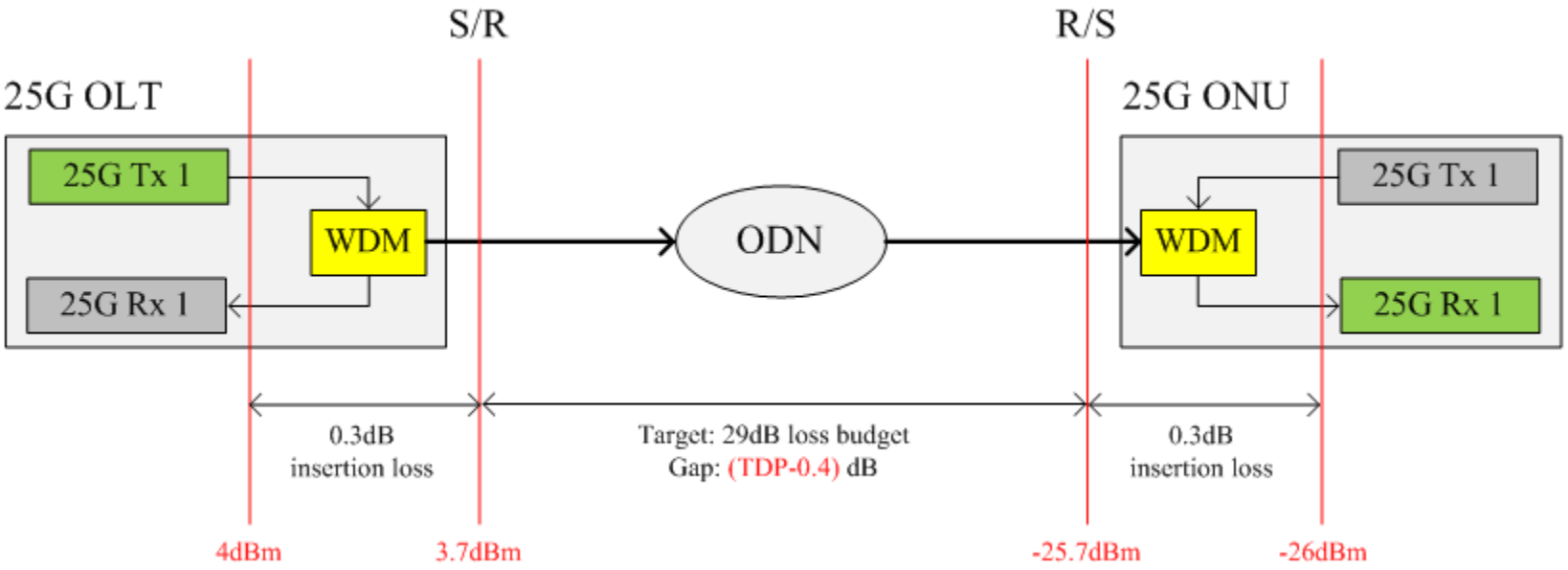
- The purpose of this contribution is to discuss the potential cost efficient solutions for 25G EPON with the help of enhanced FEC
- In this contribution, we will cover
  - Loss budget analysis for various transceivers
  - Potential enhanced FEC candidates

Assumed optical values

- 25G embedded WDM adds ~0.3dB insertion loss
- PR30 loss budget
- Downstream/Upstream TDP ranges from 1.0 to 2.0dB. Ref: tanaka_3ca_1_0516.pdf
- Burst penalty for upstream is 1.5dB
- Launch power and receiver sensitivity values from tanaka_3ca_1_0516.pdf and funada_3ca_1_0516.pdf

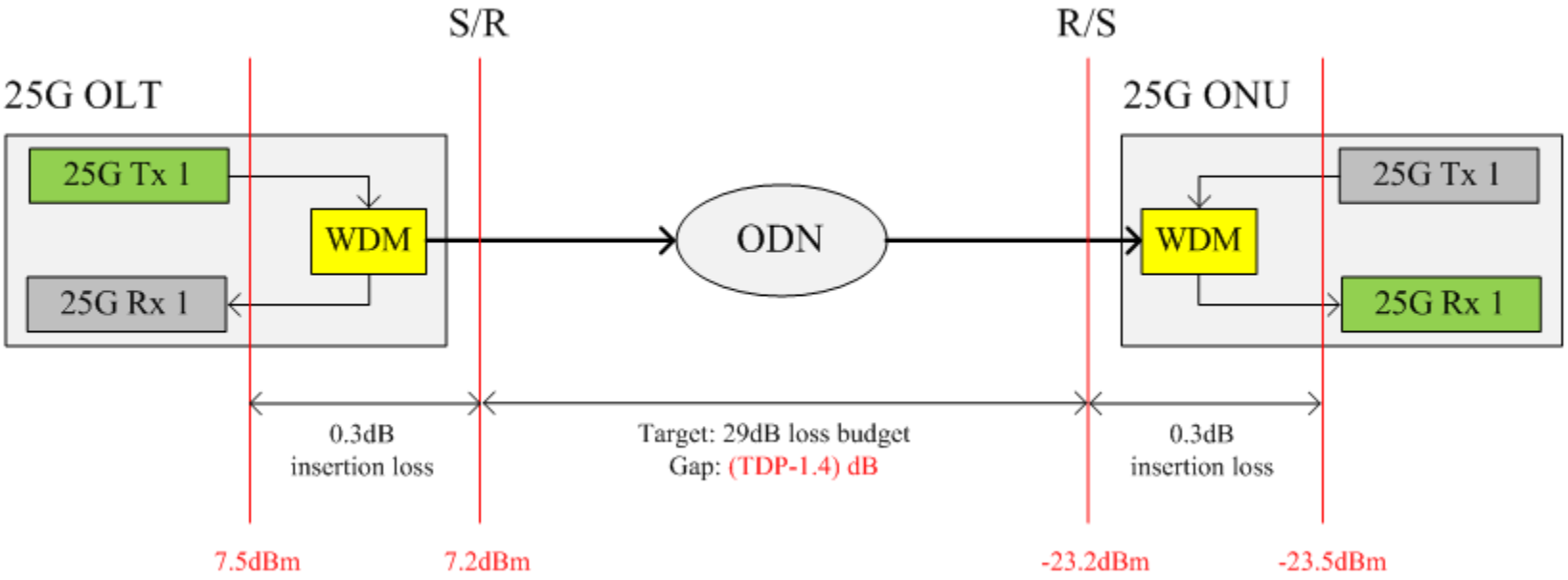
Parameter	EML scenario	Cooled DML scenario	Uncooled DML scenario
Launch power(dBm)	4	7.5	6.5
ER(dB)	8	6	6
Receiver sensitivity(dBm) @ BER=1.0e-3	-26	-23.5	-23.5

Case 1: EML for downstream



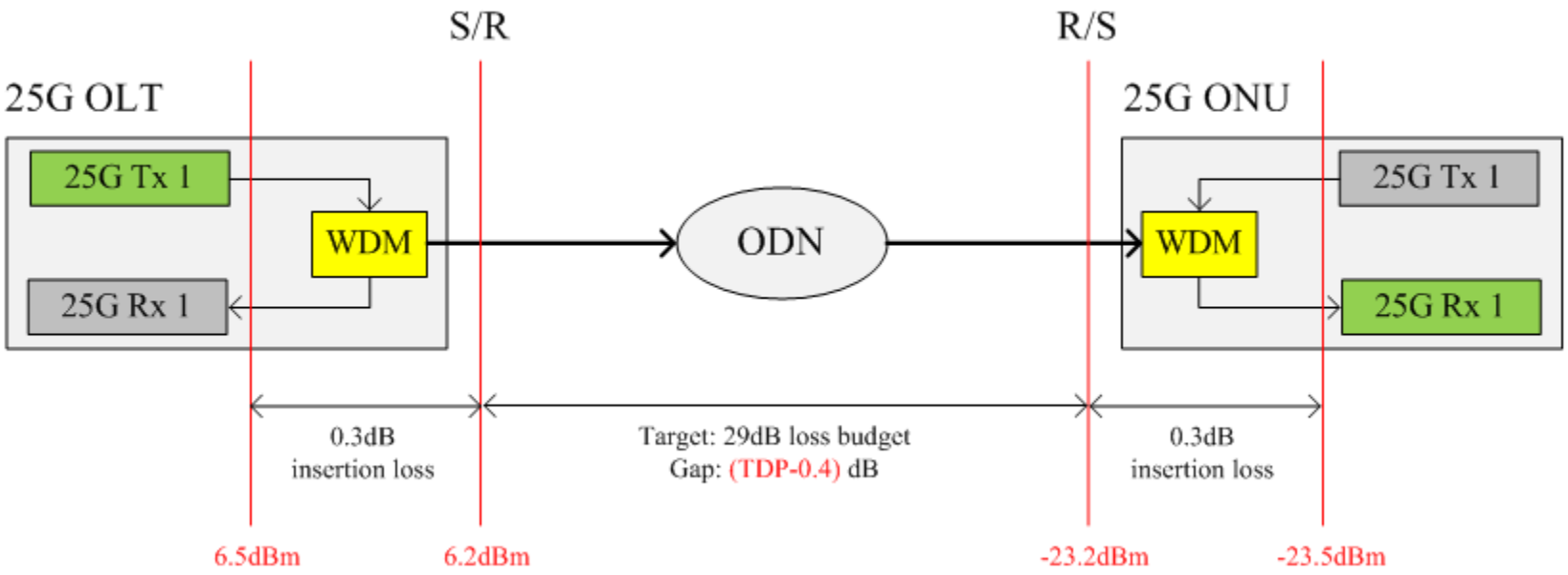
	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	3.7	-25.7	t.b.c	TDP-0.4

Case 2: Cooled DML for downstream



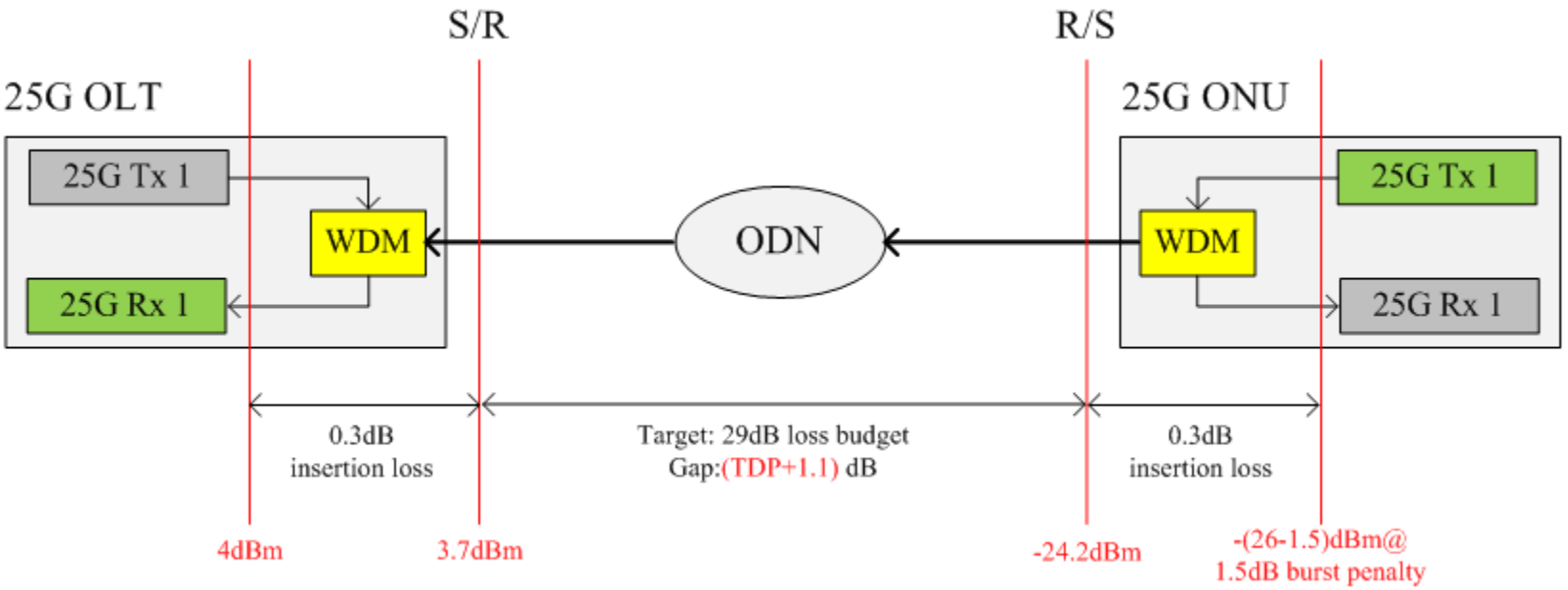
	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	7.2	-23.2	t.b.c	TDP-1.4

Case 3: Uncooled DML for downstream



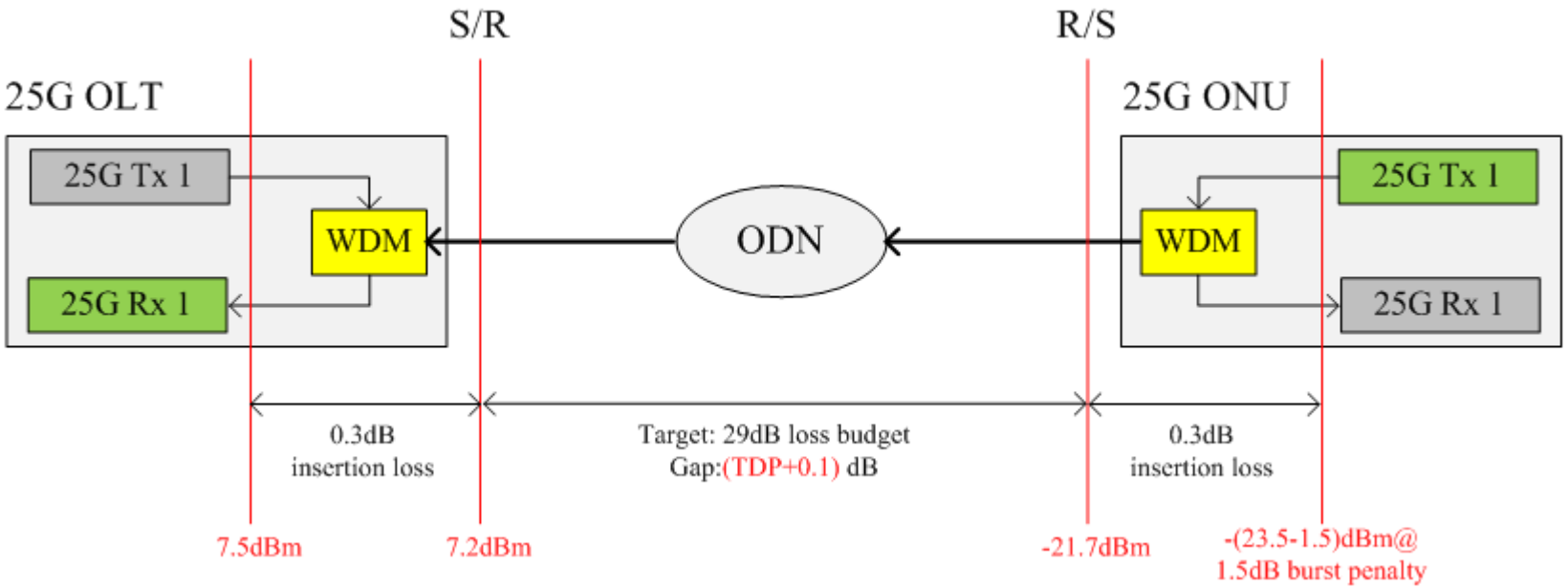
	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	6.2	-23.2	t.b.c	TDP-0.4

Case 4: EML for upstream



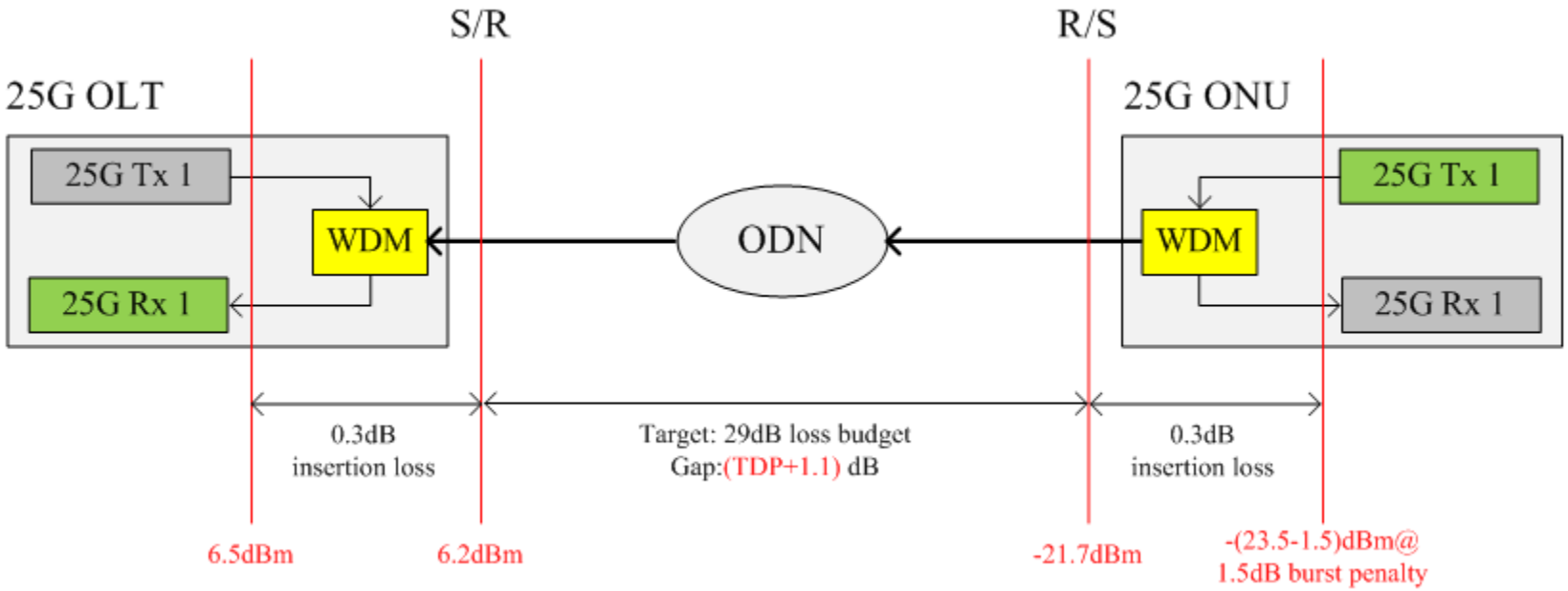
	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	3.7	-24.2	t.b.c	TDP+1.1

Case 5: Cooled DML for upstream



	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	7.2	-21.7	t.b.c	TDP+0.1

Case 6: Uncooled DML for upstream



	Launch Power(dBm)	Receiver Sensitivity(dBm) @ BER=1.0e-3	TDP(dB)	Gap=Required FEC improvement (dB)
Parameter	6.2	-21.7	t.b.c	TDP+1.1

Required FEC gain improvement summary

Scenario	EML	Cooled DML	Uncooled DML
Downstream Gap(dB)	TDP-0.4	TDP-1.4	TDP-0.4
Upstream Gap(dB)	TDP+1.1	TDP+0.1	TDP+1.1

- The downstream FEC gain gap for Uncooled DML and EML cases is TDP-0.4 dB, which corresponds to 0.6dB~1.6dB when the TDP ranges from 1dB to 2dB. For Cooled DML case, the gap is TDP-1.4dB, ranging from -0.4dB to 0.6dB. That means 25G EPON is able to reach PR30 loss budget in the downstream with an enhanced FEC of 1dB~2dB gain improvement.

- In the upstream, the loss budget gap for EML and Uncooled DML cases will be over 3dB when the TDP is set to be 2dB, which is hard to reach via an enhanced FEC; For Cooled DML case, the gap is TDP+0.1 dB, which ranges from 1.1dB to 2.1dB when TDP is within 1dB~2dB.

Enhanced FEC example

The hard decoding FEC codes listed in the following table can provide 1dB and 2dB more coding gain than RS(255,223) which provides 7.1dB of electrical coding gain.

Enhanced FEC example for 1dB coding gain improvement				
FEC code	Decision	Length(bit)	Code rate	Electrical coding gain(dBe) @e-12
RS(1023,847)	Hard	10230	0.83	8.5
BCH(4095,3501)	Hard	4095	0.85	8.5
LDPC(16000,13952)	Hard	16000	0.87	8.9
LDPC(8000,6848)	Hard	8000	0.86	8.8

Enhanced FEC example for 2dB coding gain improvement				
FEC code	Decision	Length(bit)	Code rate	Electrical coding gain(dBe) @e-12
RS(2047,1431)	Hard	10230	0.70	9.6
BCH(4095,3081)	Hard	4095	0.75	9.6
BCH(186,161) X BCH(209,184)	Hard	38874	0.76	10.5
LDPC(19200,16000)	Hard	19200	0.83	9.6

Final thoughts

- Based on above analysis, the cost efficient solution for the downstream is Uncooled DML and the required optical FEC gain improvement is about 1dB when the downstream TDP is set to 1.5dB.

- Similarly, the cost efficient solution for the upstream is Cooled DML, and the required optical FEC gain improvement is 2dB with TDP of 2dB.

- Hard decoding enhanced FEC is able to improve the coding gain up to 2dB; the complexity and burst error capability need to be considered carefully in the future.

Thank you

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