Simplified temporal specification for 10GBASE-LR/LW (1310 nm serial)

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Motivation

- Don’t want to cost more than SONET
- Cost in building transmitter
- Cost of measurement
- Thermal

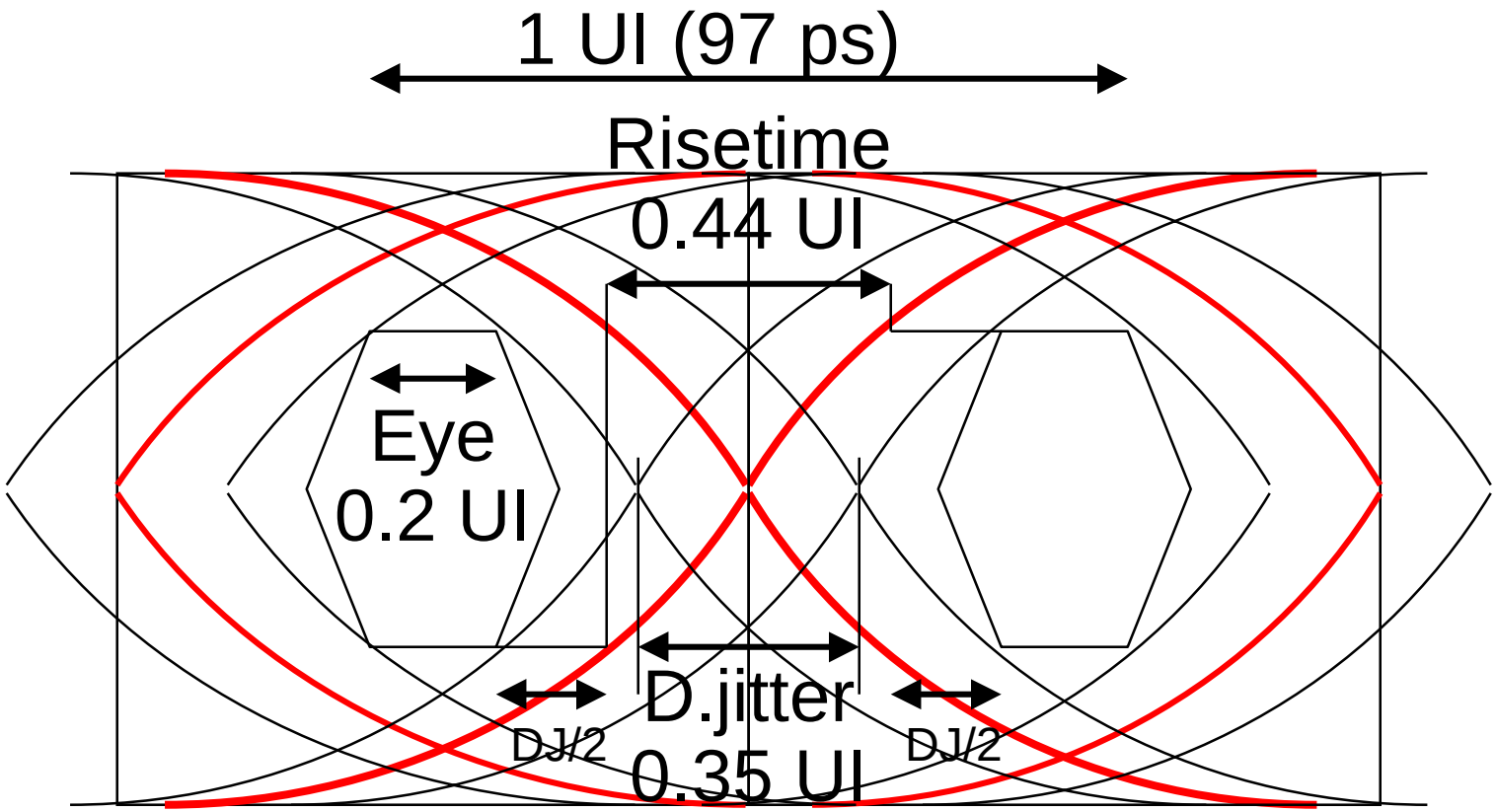
Cost in building transmitter

- Bandwidth costs $
- Lasers can't be scaled like MOS, evolve slower than Moore's Law
- Already the LAN PHY has to run approx. 4% faster than OC-192 or WAN PHY
- Risetime spec. we have may mean Tx be >10% faster again
- Hot lasers are slower: issue with port density

Cost of measurement

- Three time-domain transmitter metrics where two would do
  - 1. Eye mask Transition < 1 UI - eye mask length (seen through standard Bessel filter)
  - 2. Rise time
  - 3. (Ethernet's) Jitter
    Approximately, DJ only.
    Measured through standard Bessel filter
- One of these metrics is redundant!

Eye + Rise + Djitter <= 1



Eye mask imposes (Risetime+Jitter) < 0.8 UI

Risetime is redundant if numbers add up

Compare optical standards 1 of 2

- SDH and SONET
  - Single mode fiber
  - Little ISI from link (very high fiber bandwidth)
  - 1. Eye mask
  - 2. Jitter up to B/2500 Hz
- Fibre Channel and 1G Ethernet
  - Multi mode fiber
  - Much ISI from link (limited link bandwidth)
  - 1. Eye mask
  - 2. Rise time ← *Additional*
  - 3. Jitter up to B/2 Hz ← *More stringent*
- 10GE draft 3.0 Three kinds (see next slide)

Compare standards 2 of 2: 10GE draft 3.0

- 850 nm serial
  - Multi mode fiber, much ISI
  - 1. Eye mask
  - 2. Rise time
  - 3. Jitter up to B/2 Hz
- 1310 nm serial
  - Single mode fiber, less ISI
  - 1. Eye mask
  - 2. Rise time ← *This can be superfluous*
  - 3. Jitter up to B/2 Hz
- 1550 nm serial
  - Single mode fiber, moderate ISI
  - 1. Eye mask
  - 2. Rise time ← *maybe this too for a different reason*
  - 3. Jitter up to B/2 Hz

Proposition

For 1310 nm serial:

- Tx eye and high SMF bandwidth guarantee useable eye at Rx
- 802.3ae's new very thorough jitter measurement, and high SMF bandwidth, guarantee useable jitter at CDR
- Risetime is of no interest to Rx or CDR, it is only a means to an end

- Let's specify the end not the means

Timing budget as draft 3.0

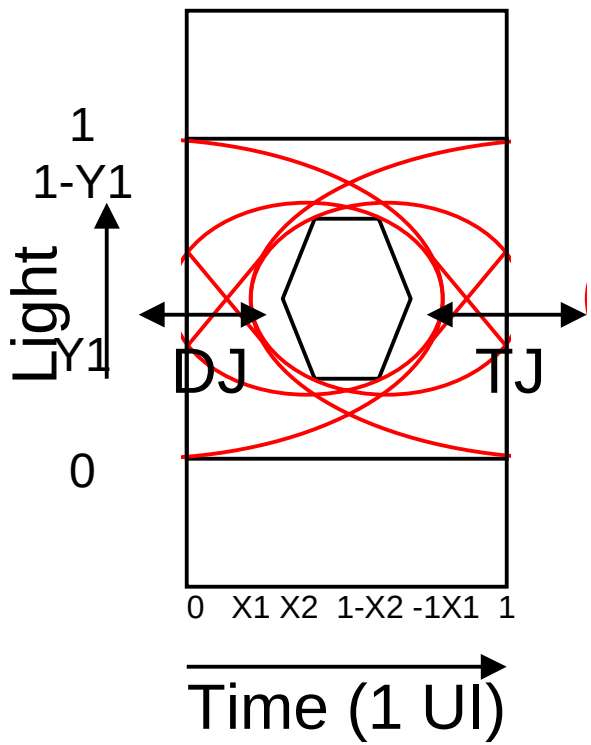
	UI	ps
Eye mask	0.2	19
Risetimes (25%-75%)		
Tx r'time (40 ps 20-80%)	*0.33*	*32*
Link risetime	*0.20*	*19*
Rx risetime	*0.22*	*22*
RSS: total risetime	0.44	43
Det. Jitter	0.35	34
Eye+Rise+DJ	0.99	96
(One bit =	1	97)

Remainder (1 ps) is for RJ & Tx noise at 3sigma

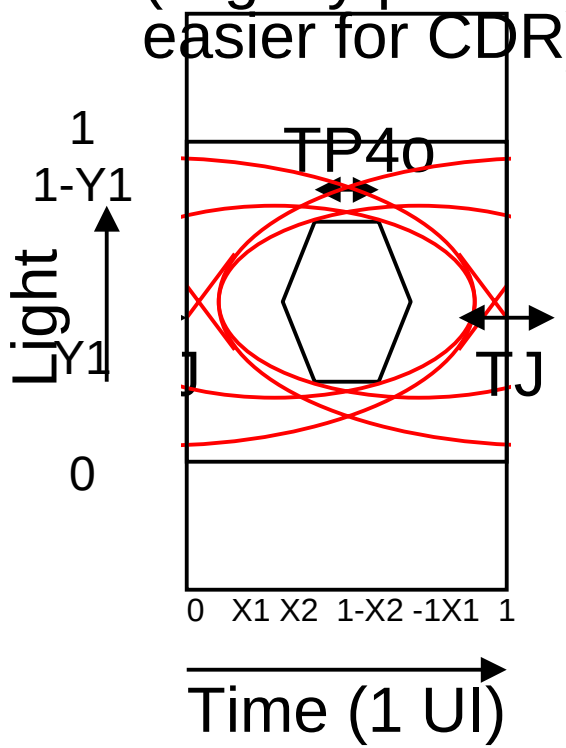
Tx risetime spec is superfluous with this much DJ

Two equivalent eyes

Allowed
More DJ
Faster edges



Forbidden
Less DJ
Slower edges
(slightly preferable: easier for CDR)



Two equivalent eyes: timing budgets

	UI	ps		UI	ps
Eye mask	0.2	19		0.2	19
Risetimes (25%-75%)					
Tx risetime	*0.33*	*32*		*0.53*	*51*
Link r'time	*0.20*	*19*		*0.20*	*19*
Rx risetime	*0.22*	*22*		*0.22*	*22*
RSS: total risetime	0.44	43		0.61	59
Det. Jitter	0.35	34		0.15	15
Eye+Rise+DJ	0.99	96		0.96	93
One bit =	1.00	97		1.00	97
Remainder for RJ & Tx noise at 3σ	0.01	1		0.04	4

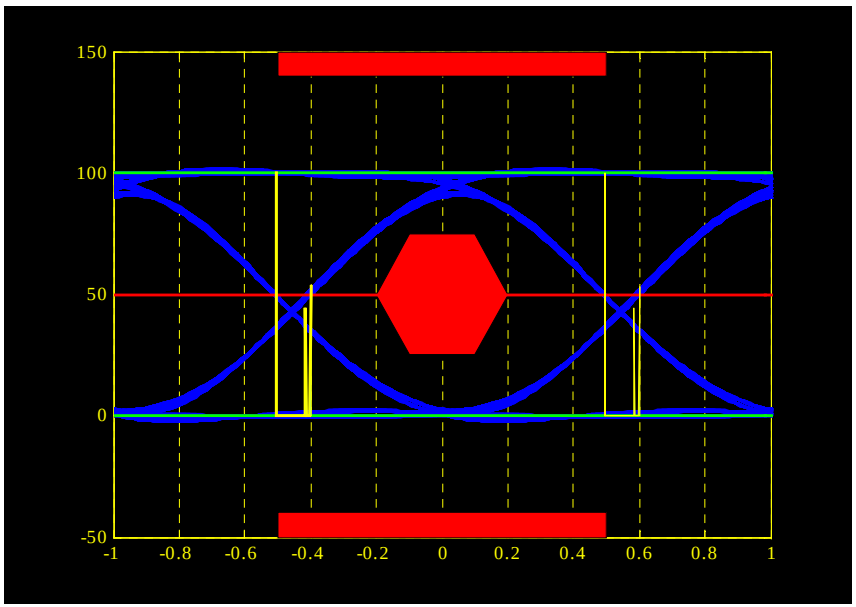
Same mask margin

Simulations: trading rise time and DJ

Viewed at receiver, transfer function filter order N=4 (N=1 gives similar conclusion). Using DCD to simulate DJ

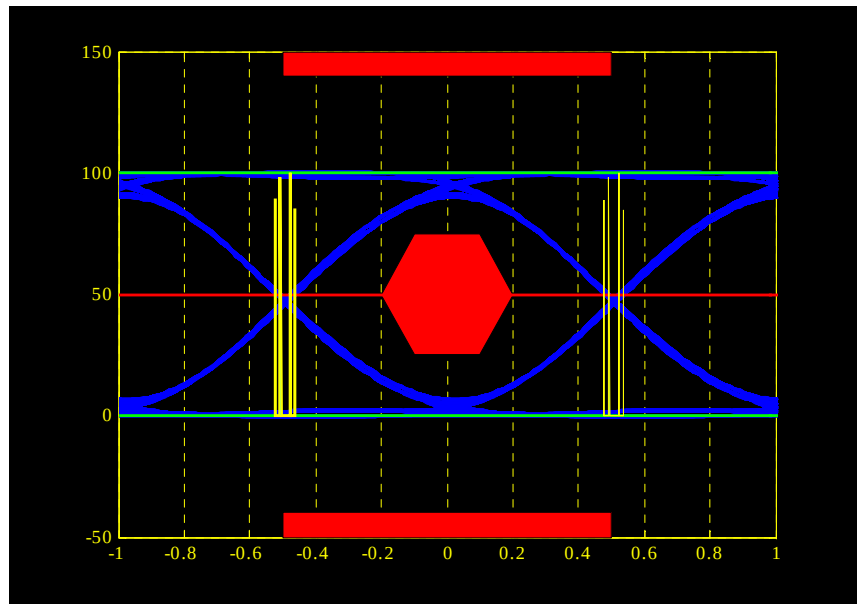
Trading off 10 ps more 10-90% rise time for 4 ps DJ adds <0.1 dB additional ISI penalty

Parameters in simulation aren't the same as previous slide (32*1.26*1.518=61ps, 51*1.26*1.518=97ps)



RX BW=7725 MHz; Nfilter=4;

Trise(10-90)=61ps; DJ@TP2=13 ps
DJ@TP35=12 ps; ISI @TP35=0.9 dB



RX BW=7725 MHz; Nfilter=4;

Trise (10-90)=71.3ps; DJ@TP2=8.7 ps;
DJ@TP35=9.0 ps;ISI @TP35=0.98 dB

Proposed changes

- 1. Keep eye and jitter specs the same
- 2. Keep Tx power the same
- 3. Keep Rx the same
- 4. Keep link attenuation the same
- 5. Delete risetime requirement

Result of proposed changes

- Simpler standard
- Implementers can (implicitly) trade off Tx DJ and speed
  - More design freedom
  - But without the complexity of trade off curves
  - Speed and jitter typically do trade off in practice

Conclusion

- Proposed changes will make the 10GBASE-LX (and -LW) transmitter

  Cheaper, or

  Able to run hotter
- This may benefit port density