Possible tools for improving performance in electrical links

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Motivation

- In P802.3ck we are doubling the data rate and the signaling rate
- IL targets compared to previous generations:
  - For cable/backplane – somewhat lower (28 dB vs. 30 dB)
  - For C2M – likely higher (14? vs. 10 dB)
  - C2C?
- However loss is not everything
  - UI length is halved – signal integrity cares for smaller features
  - Reflections and crosstalk are harder to control
  - Even with very good equalization, the SNR denominator is a challenge
- We look at channels between test points, adding reference pacakges – this is optimistic
  - Well matched terminations
  - No package crosstalk
- Real life implementations may not be as good

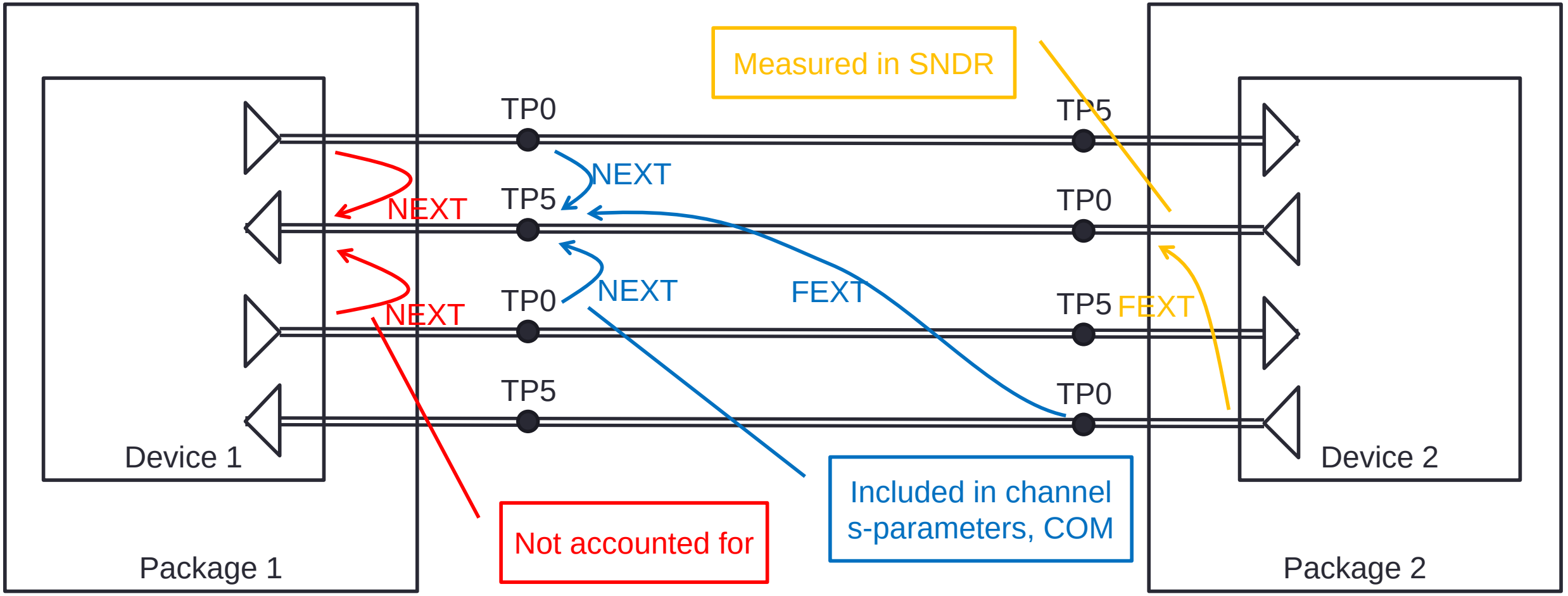
Past results from 802.3cd

- Yasuo Hidaka has shown in several presentations that mismatches between device and channel impedance can affect COM results
  - See hidaka_3cd_01a_0317, hidaka_3cd_01a_0517, hidaka_3cd_01_0717
  - In a few combinations of package and device impedances, degradations of up to ~1 dB, but also possible improvements of up to ~0.5 compared to nominal values
  - Hidaka suggested including a gap in COM between RITT calibrations and channel specs
    - To account for variations of devices connected to a channel
    - It was not adopted
- We also added ERL after considerable work by Rich Mellitz
  - Now devices have meaningful specs controlling their reflections!
  - … but we also made COM better for “nominal” channels by using “nominal” terminations
  - As demonstrated in dudek_3cd_01a_0718 there bad results are possible with devices that meet the Tx and ERL specifications, and cables that meet COM specifications
- We have a noise budget deficit…
  - It may be mitigated by statistics (“not all things are worst case at the same time”)

Specs and practice

- The Ethernet standards had a nominal impedance of 100 Ohms for multiple generations
- Practical packages are designed with lower impedance
  - Nominal may be 85-90 Ohms
  - Various motivations
  - Deviations from the nominal may adversely impact RL, but that was seen as a secondary concern
- Operation of these packages may be better with matched channel impedance (e.g. 90 Ohm)
  - Some channels may be designed this way
- Nominal device termination is also 100 Ohm
  - But optimal performance with a given package and channel may require different termination
  - Some devices have configurable terminations
  - Work done for this project suggests 90 Ohm may be more adequate
- Should we keep assuming 100 Ohm?

Package crosstalk



Crosstalk issues

- Controlling crosstalk at high bandwidth channels (>30 GHz Rx bandwidth) can be challenging
  - Especially in packages and connectors
  - We should consider penalties of multi-lane package implementation
- Package NEXT in particular is not measured; only affects receiver (which has 3 dB allowance)
  - At 100 Gb/s, it may limit lane density or reach
  - Current channel data does not include package NEXT
- NEXT and FEXT have been issues in the BASE-T world for a long time
  - NEXT cancellation is not a normative requirement, but it is practically required, and relatively simple
  - FEXT cancellation is more complex and has lower ROI
  - Enabled by using loop timing
- Can we enable NEXT cancellation?

Possible paths for exploration

- Change the reference impedance to 90 Ohm
  - Seems to better match practice
- Programmable device termination
  - Why?
    - Can enable covering a larger space of channels
    - Can increase design freedom of packages and channels
  - We can define a few values and some management register bits
    - How to optimize may be out of scope
  - There are some existing specs that will be affected
    - ERL
    - COM
- NEXT cancellation
  - Why?
    - Can improve margins for receivers when NEXT is dominant
    - Can increase design freedom of packages and channels
  - Loop timing is a known requirement; Can we have it in the BASE-R architecture?
    - Implementation of “slave mode” already possible today, transparently
    - Can be an optional feature
    - Synchronous Ethernet already has something similar
  - We can define management register bits for slave capability and enable/disable
    - But need to prevent “mutual slave” configurations
    - Easy in KR/CR with AN/training; a solution for optics is required

Summary

- Impedance matching and crosstalk may strongly affect electrical link performance at 100 Gb/s
- Using new tools may help achieve our objectives
- More discussion is welcome