40 GbE Over 4-lane 802.3ap Compliant Backplane

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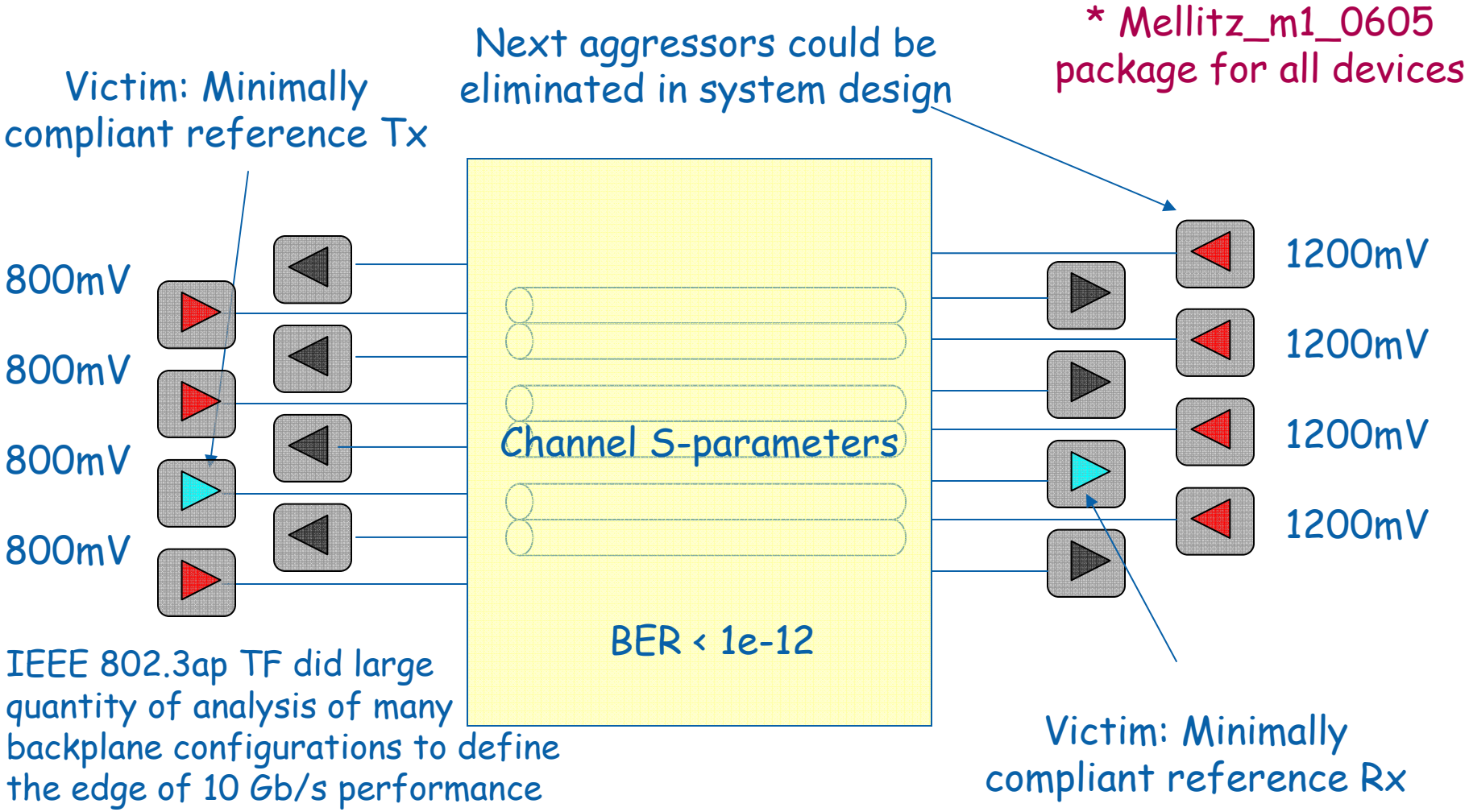
Agenda

- 40 GbE proposition
- 40 GbE system configuration
- Practical backplane design considerations for 40 GbE
- Summary

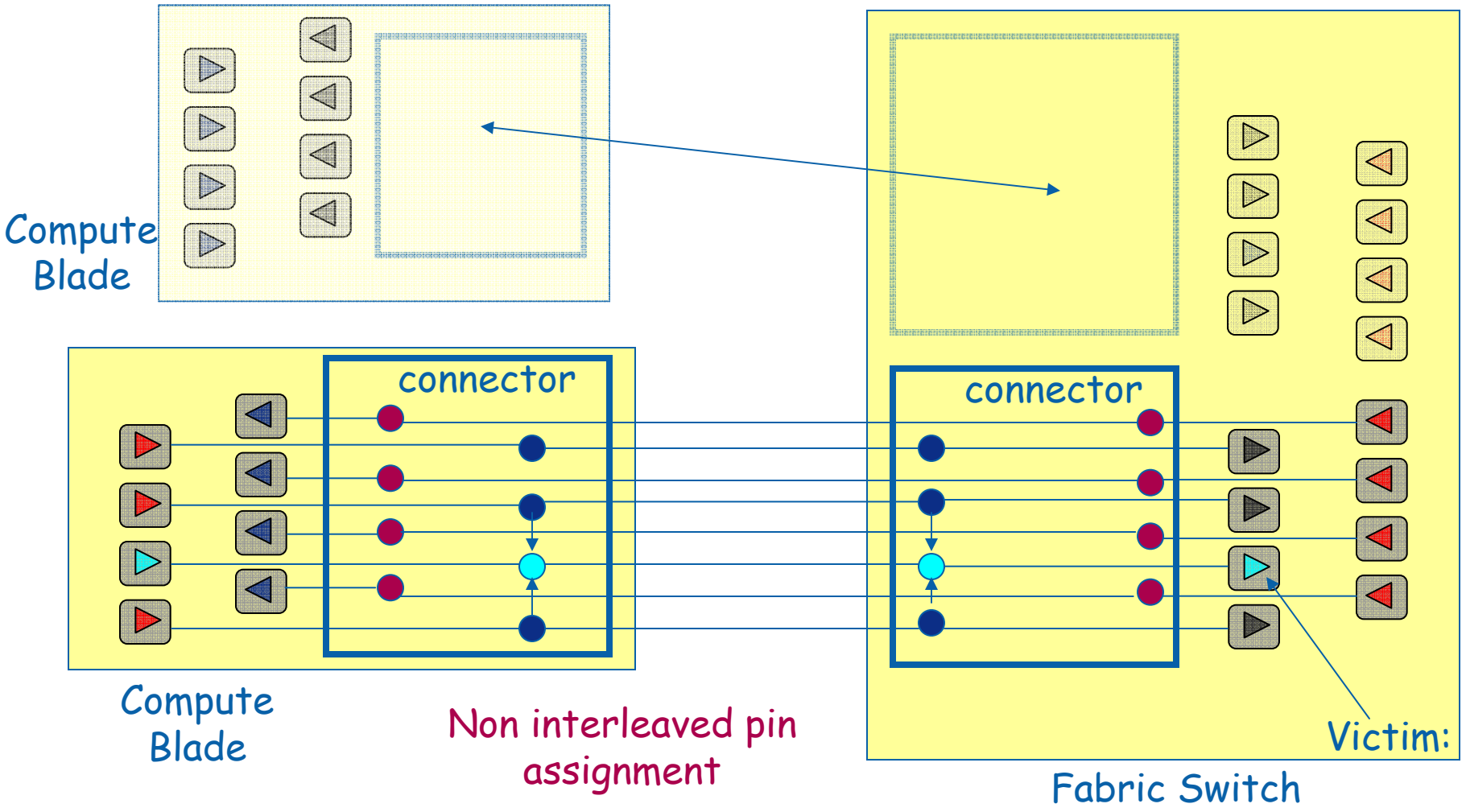
Proposition: IEEE 802.3ap KR already has electrical specification to support 40 GbE backplane: Connect the dots…

- IEEE 802.3ap 10GBASE-KR 10GbE is a standard that supports:
  - 10 Gb/s serial data transmission using 64/66B encoding.
  - Multiple agent crosstalk budgeting
  - Normative SerDes silicon
  - 1 meter of enhanced FR4 with up to 2 connectors
  - Backplane design can make trade offs that support a wide range of industry applications
- Consequently there is inherent 40 GbE **support for:**
  - **40 Gb/s** on 4 lanes of 10 Gb/s serial transmission
  - Existing backplanes designed with 802.3ap KR in mind
- Recommendation: Adopt IEEE 802.3ap 10GBASE-KR as a baseline for 40GbE backplane

40GbE Setup Configuration for BER Evaluation:



Bundling in a 40GbE system will reduce the crosstalk penalty



Practical Considerations For a 40GbE System Design

A glance a design rules for 40 GbE

- Silicon Performance (Broadband noise)
  - Normative
- Material loss (IL)
- Scattering loss (ILD and RL)
- Crosstalk (ICR)

Examples are taken from analysis of IEEE 802.3ap publicly posted channels (References are to Tyco and Peter's channels)

Silicon Performance (Broadband noise)

- IEEE 802.3ap's goal was to provide solutions which are **widely available** at a **reasonably low power** and **cost**
- Most of the IEEE802.3ap posted channels are not compliant
  - The posted channels explore the edge of performance
  - We found the edge for any backplane system is not a razor!
- Most posted channels could work if power and cost ($$) are thrown at receivers

Material Loss

- IEEE 802.3ap KR limits material loss with the insertion loss limits.
- Supports 1 meter of enhanced FR4 with up to 2 connectors
- Widely available material and humidity limit reach
  - Some RoHS compliant materials have 3 times the loss of enhanced FR4
    - That is: only a 13 inch reach
  - Commonly available FR4 at 65% humidity is 2 times more lossy than enhanced FR4
    - That is: only 26 inch reach
    - Safe designs will have 2 to 5 inches on line cards.
- 40GbE backplane designers are provided the opportunity for choice
- “KR” tells us the that insertion loss is not the only factor
- Maximum reach will require ILD and ICR to be minimized
  - Tyco case1 is just a bit over the ILmax. Without crosstalk it will support a BER of 1e-12. Added crosstalk brings it significantly below 1e-12

(ILD: Insertion Loss Deviation ICR: Insertion Loss to Crosstalk Ratio)

Scattering loss

- Return loss is not as important as the accumulated reflections on a channel.
  - This is captured with ILD (Insertion Loss Deviation)
- Peters B1 and M1 are good examples of resonance severely limiting the BER of a channel
  - B1 is a bottom route with a 25 mil via stub
  - M1 is a middle route with a 70 mil via stub
  - The BER of Peters B1 is ~ 1e-13 while Peters M1 fails with BER >1e-10
- The issue here is that the backplane spacing of 1 inch between connectors reverberates the via stub discontinuities.
  - B20 and M20 (20" backplane) have BER < 1e-12
  - The dampening of reverberations enable a lower BER even thought total channel loss is greater
- A good 40 GbE design rule would be to require backplane routing to be 4 inches or greater. The longest length is dictated by insertion loss
- Line cards (at least blades) should use bottom layer routing
- Via stubs on line cards are also quality factors. This evaluated with TDR form s-parameters of the channel. Management of line card vias can improve system BER

Crosstalk

- Crosstalk is a **very** strong qualifying factor
- Peters B1, M20, B20 and Tyco case 1, case 2, and case 4 pass until posted crosstalk is added
- Peters B12 (12 inch backplane) is tolerant of all but the maximum crosstalk. B20 has some tolerance to crosstalk
- A 40GbE backplane design having routed lengths between 4 and 12 inches has head room to manage crosstalk
- 40GbE by four bundling helps to manage crosstalk
  - This is an advantage that 40GbE can take
- Crosstalk will be minimized if spacing between pairs is at least 4 times the height of the traces over the reference plane for striplines.
  - For microstrip, the number is at least 7 times

Summary

Based on

- IEEE802.ap KR Receivers/Transmitters
- Evaluating data from the published channels
- The aforementioned design guidelines

Adoption of IEEE 802.3ap 10GBASE-KR as a baseline for 40GbE backplane is a natural progression.

Many post “IEEE 802.3ap” backplane systems have employed methods that insure IEEE 802.ap compliance. These system are well positioned to work with this 40GbE proposition.