Co-Optimization of SerDes Channels using AMI Modeling

Walter Katz
Signal Integrity Software, Inc.
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Overview

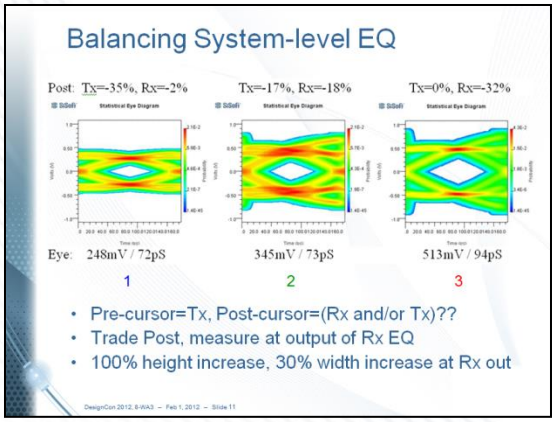
- Co-Optimization background
- Why Co-Optimize?
- Co-Optimization Methods
- Optimization Examples
- Two proposals, two methods
- SiSoft proposal: IBIS AMI – Tx, IBIS AMI – Rx
- Optional Private Protocol
- Advantages of SiSoft Approach
- Next Steps

Co-Optimization Background

- What is Co-Optimization
  - An operation in which the Equalization characteristics of the TX and RX are simultaneously adjusted to identify the optimal setting that maximizes one or more characteristics of a channels performance
    - Characteristics include Eye height, Eye width, Power, BER, etc.
- How does Co-Optimization work in the hardware
  - Performed via communication protocol between the TX and RX via a “Back channel” connection
    - Current SerDes protocols that define a backchannel
      - 802.3kr
      - 802.3bj
      - PCIe Gen3

Why Co-Optimize?

1. Emulate backchannel adaptation defined by current SerDes protocols (802.3kr, 802.3bj, PCIe Gen3)
2. Sequentially optimizing TX and RX SerDes settings does not maximize system margin:



"Simulating Large Systems with Thousands of Serial Links"

SI Guys / Ericsson / SiSoft
DesignCon 2012

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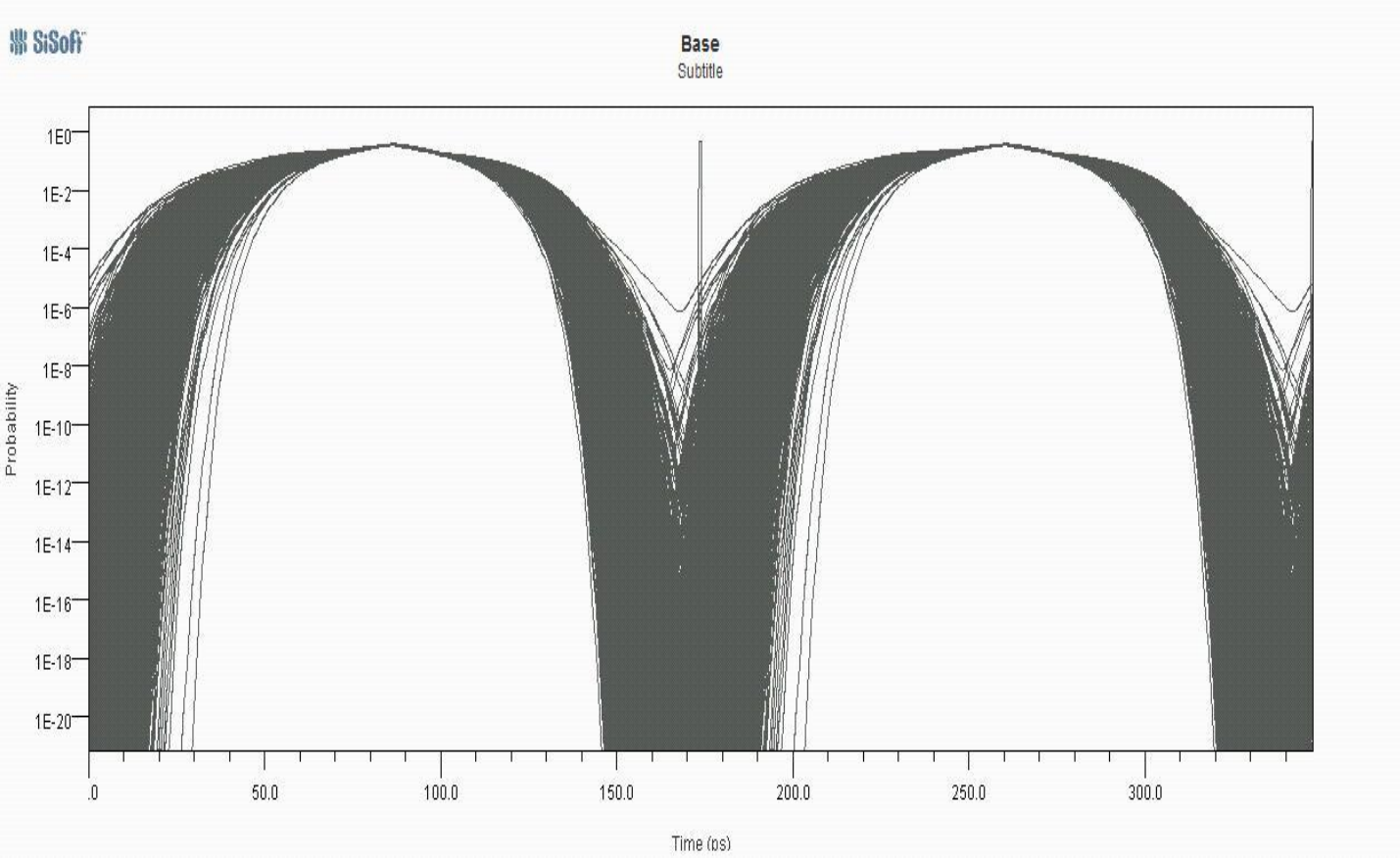
Backchannel Adaptation

- Multiple standards support it
  - 802.3kr
  - 802.3bj
  - PCIeG3
  - PCIeG4
- Simulation can model the adaptation process and predict how the hardware will converge
  - Co-optimize Tx and Rx settings based on simulation of hardware adaptation protocol
  - Simulated Tx and Rx settings can be compared to hardware results

Protocol-Agnostic Co-Optimization

- Simulation can also be used to explore different Tx – Rx combinations and optimize for different design criteria:
  - Maximum eye height at Rx
  - Maximum eye area at Rx
  - Minimal Tx output power
  - …
- Tx / Rx settings for these criteria may or may not correspond to settings resulting from the standard hardware backchannel adaptation algorithms

Tx Taps Optimized for Eye at Input to Rx



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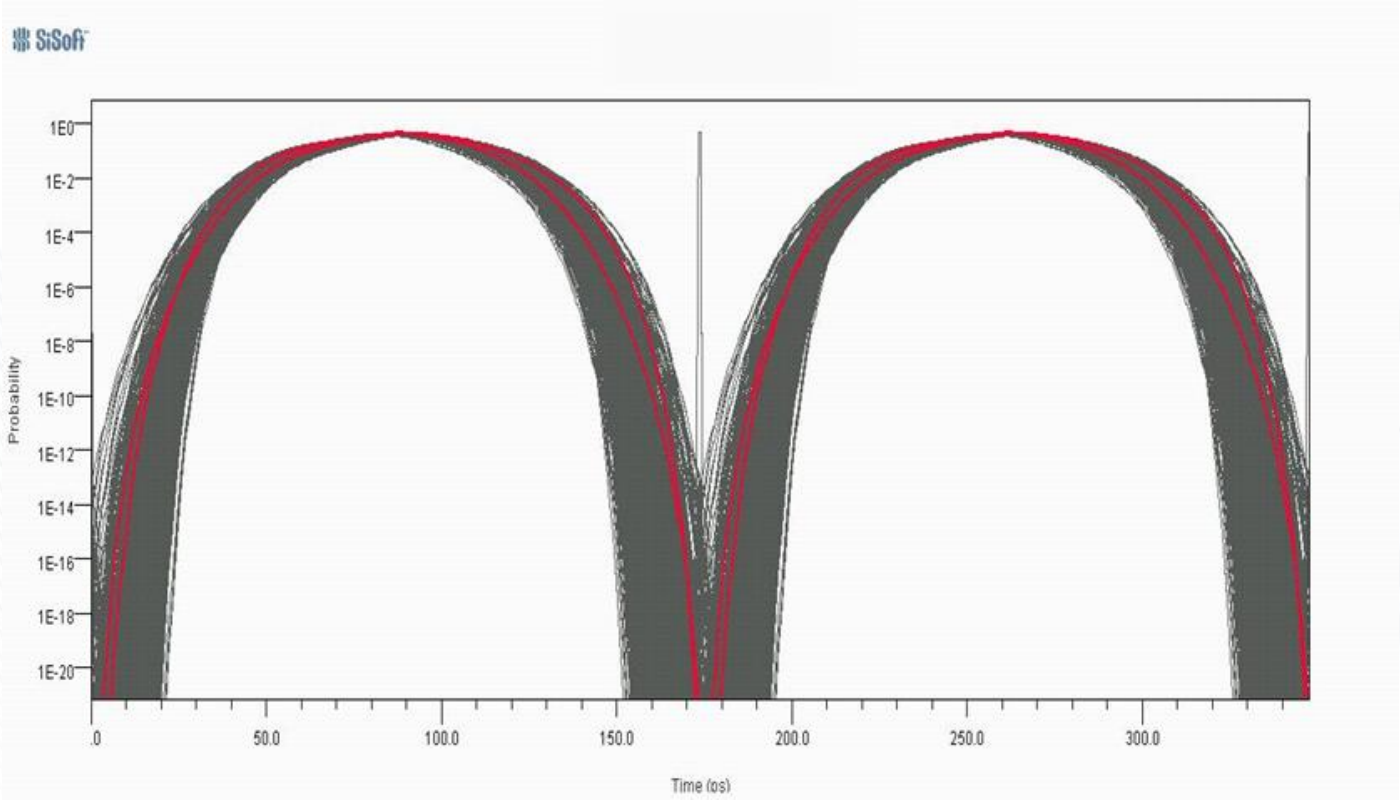
Tx/Rx Co-Optimization Example



- This is an example of the performance gains possible with backchannel adaptation approaches

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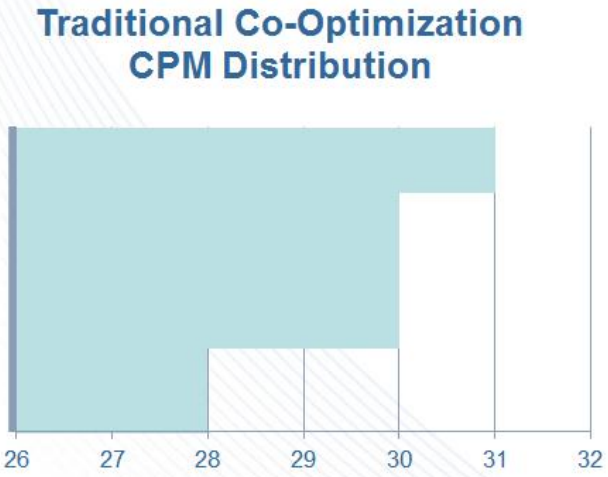
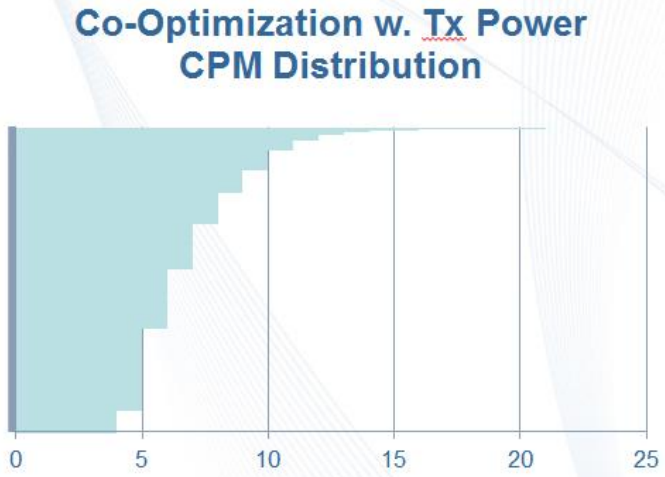
Tx/Rx Co-Optimization: Power

Total CPM (Consolidated Power Metric)

Traditional Optimization	> 37,500
Optimization w. Tx Power	< 9,000





- These types of performance gains require more than just emulating hardware adaptation protocols

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Co-Optimization Methods

- Time-Domain (GetWave) Training (Backchannel)
  - Targeted at emulating hardware adaptation protocol
    - Training may take millions of UI to converge
    - Assuming just 10^6 UI, simulations will take ~ 1 minute
    - 5000 channels will take ~5000 minutes (~100 hours)
- Statistical (Init) Co-Optimization
  - Targeted at exploring options and optimizing based on different metrics
    - Simulation times are ~ 1 second
    - 5000 channels will take ~5000 seconds (~2 hours)
    - System Integrators can (and do) evaluate many engineering decisions such as
      - PCB materials
      - IC Vendor and buffer IP selection
      - Via manufacturing technology

Two Proposals

	SiSoft	Cadence
Primary Focus	Enable System-level exploration and optimization	Model hardware backchannel adaptation
Secondary Focus	Model hardware backchannel adaptation	Enable System-level exploration and optimization
Method	Protocol-agnostic parameters in .ami files	Protocol-specific .bci files

SiSoft Proposal: IBIS AMI - Tx

- Add Reserved Parameters to enable Tx to publish its tap configuration
  - Number of Pre-Cursor Taps
  - Number of Post-Cursor Taps
  - Tap Coefficient Ranges
  - Tap Resolution (Tap Indexes)
  - Peak to Peak Voltage
- Add to Tx DLL (Init and GetWave) the ability to accept tap configuration recommendations
  - Tap Coefficients
  - Tap Indexes
  - Tap Increments
  - Peak to Peak Voltage

SiSoft Proposal: IBIS AMI - Rx

- Add Reserved Parameters to enable Rx to discover the Tx published tap configuration
- Add to Rx DLL (Init and GetWave) the ability to adjust the TX tap configuration
- Add Reserved Parameters to control training and co-optimization.
  - Turn on and off training
  - Define training pattern stimulus pattern

Private Training Protocol

- Allow a new Reserved String Parameter to both Tx and Rx to allow message to be sent back and forth between Tx Init, Rx Init, Tx GetWave and Rx GetWave.
- This is a true Black Box protocol, that will work with any EDA tool that will support this message passing method.

Advantages of SiSoft Approach

- Existing Tx DLLs can be used for co-optimization through new Reserved Parameters
- Tx model can report optimized tap coefficients through standard means (AMI Parameters_Out)
- No.bci files or associated approval processes
- Enables EDA tools to co-optimize channels that do not support backchannel training
- Enable EDA tools to optimize beyond solutions found by hardware backchannel adaptation

Next Steps

- The IBIS-ATM working group meets each Tuesday from Noon – 1PM Pacific time.
- The group is currently deciding which proposal to use as the basis for its efforts
- Work Archives at
  - http://www.eda.org/ibis/macromodel_wip/archive-date.html