AMI Backchannel Co-Optimization

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Overview

- What is a Backchannel?

- Where are Backchannels used?

- Simulating Backchannel Optimization

- Standardizing Backchannel Modeling

- Who Needs Backchannel Models?

- IBIS-AMI Backchannel Reflector

- Summary

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What is a Backchannel?

- A communication path allowing a SerDes receiver (Rx) to configure its corresponding transmitter (Tx) *in-situ*, co-optimizing transmit and receiver (RX) settings for a specific channel.

TX1

10GBASE-KR_TX

RX1

10GBASE-KR_RX

S1
s_tyco_16

Backchannel

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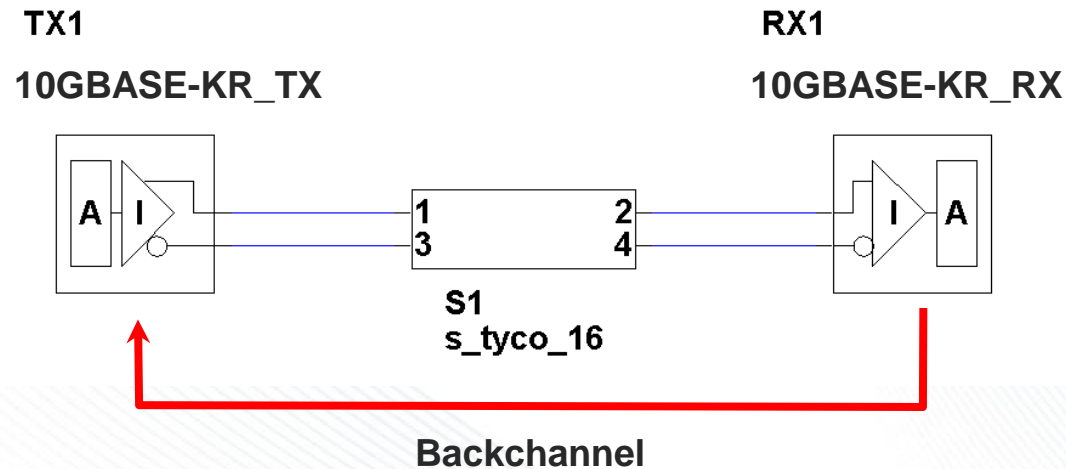
Why Use a Backchannel?

- Each channel optimizes itself automatically
  - Increased margin: each channel optimized for the specific TX/RX/PCB process corner
  - Reduced lab/simulation time: without Backchannel, months of effort are required to define EQ settings for each channel

- Allows a system to dynamically modify Tx (Upstream) registers if the Rx (Downstream) module is hot-swapped.

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Where are Backchannels Used?

- Backchannel specifications have been approved for the following communication protocols
  - PCI-SIG PCI Express Gen3
  - IEEE 802.3ap (10GBASE-KR)

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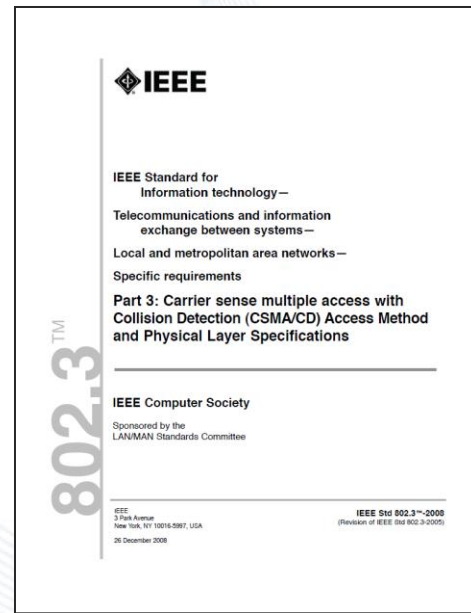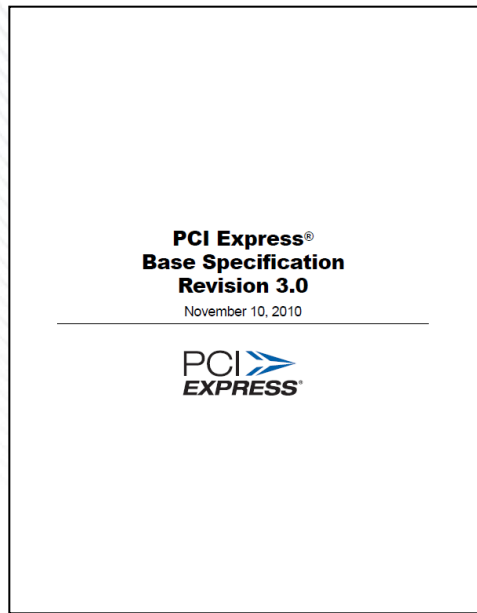
How Does a Backchannel Work?

- Details vary, but basically:
  - RX & TX enter Training Mode
  - TX sends pre-defined training pattern
  - RX evaluates & sends command (up, down, next tap)
  - Process continues until optimization is complete

- Optimization can occur one-time at power-up or can occur periodically
  - Optimizing periodically tracks changes due to temperature, device aging, etc.
  - Optimizing a running system requires interrupting traffic

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Simulating Backchannel Behavior

- Time-Domain simulation can model the actual optimization protocol:
  - Training Mode / Training Pattern / Evaluate / Repeat
  - Simulating training sequence adds to simulation time

- Statistical simulation can determine TX / RX tap coefficients directly
  - Can't model training protocol details (no stimulus)
  - RX model can still determine optimum TX/RX coefficients and communicate them
  - Impact on simulation time is minimal

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Standardizing IBIS-AMI Backchannels
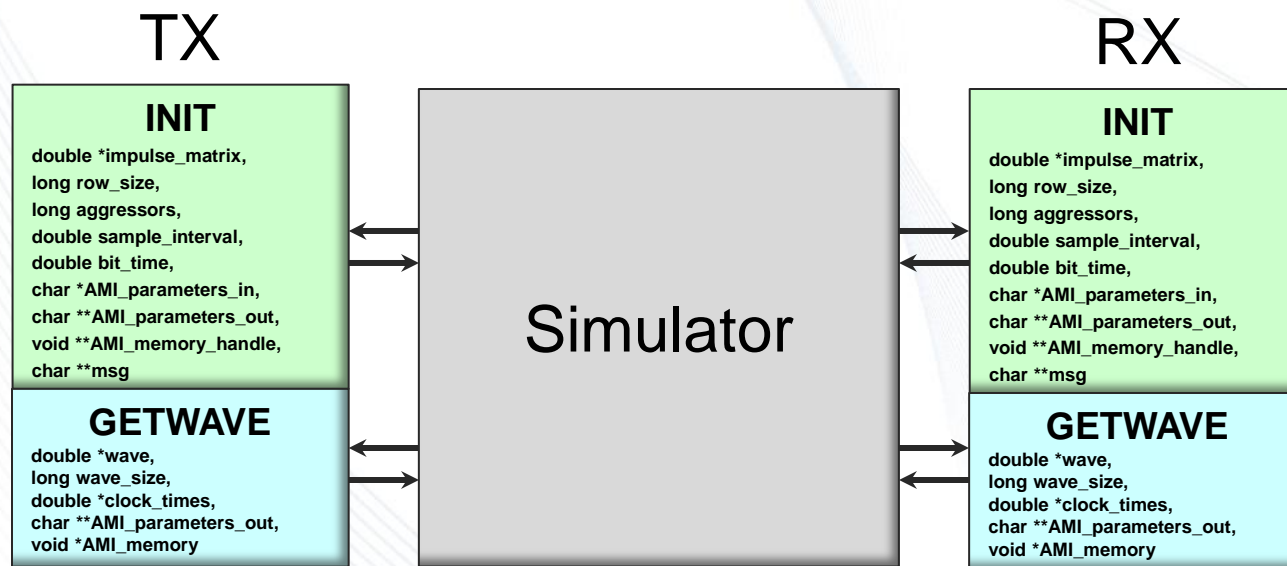
- Two things need to be standardized
  - The *communication path* between the DLLs
  - The *messages that get passed* along that path

TX1

10GBASE-KR_TX

RX1

10GBASE-KR_RX

START
TAP(-1)
UP
UP
TAP(0)
DOWN
...

**S1
s_tyco_16**

Communication Path

Messages between DLLs

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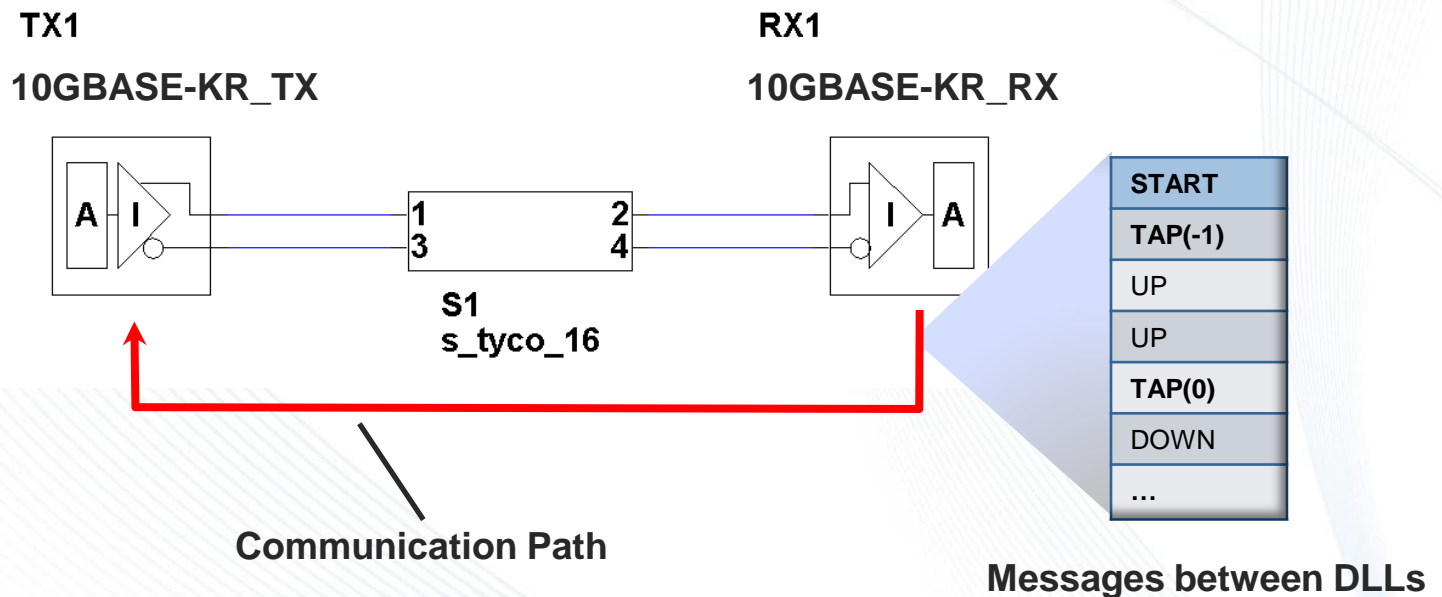
IBIS-AMI Communication Path

- Defines how data (bytes of information) is transferred between the RX and TX DLL

TX   RX

INIT

double *impulse_matrix,
long row_size,
long aggressors,
double sample_interval,
double bit_time,
char *AMI_parameters_in,
char **AMI_parameters_out,
void **AMI_memory_handle,
char **msg

GETWAVE

double *wave,
long wave_size,
double *clock_times,
char **AMI_parameters_out,
void *AMI_memory

Simulator

INIT

double *impulse_matrix,
long row_size,
long aggressors,
double sample_interval,
double bit_time,
char *AMI_parameters_in,
char **AMI_parameters_out,
void **AMI_memory_handle,
char **msg

GETWAVE

double *wave,
long wave_size,
double *clock_times,
char **AMI_parameters_out,
void *AMI_memory

- Needed for model ***portability***, ensuring a given model will work in different simulators

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Standardizing TX ➜ RX Communication

- ## AMI_Init
  - The parameters_in string sends information to the DLL. Currently this tree has the same root as the .ami file.
  - One proposal is to allow the parameters_in string to contain both the Tx and Rx trees.

- ## AMI_Getwave
  - AMI_GetWave has a char** parameters_out argument that allows the DLL to pass data back to the simulator.
  - One proposal is to "preload" the model's output area with data to be passed into the Getwave call.

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IBIS-AMI Backchannel Messages

- Define the commands between the RX and TX DLL and their meaning

TX   RX

| START |
| TAP(-1) |
| UP |
| UP |
| TAP(0) |
| DOWN |
| ... |

GETWAVE
double *wave,
long wave_size,
double *clock_times,
char **AMI_parameters_out,
void *AMI_memory

GETWAVE
double *wave,
long wave_size,
double *clock_times,
char **AMI_parameters_out,
void *AMI_memory
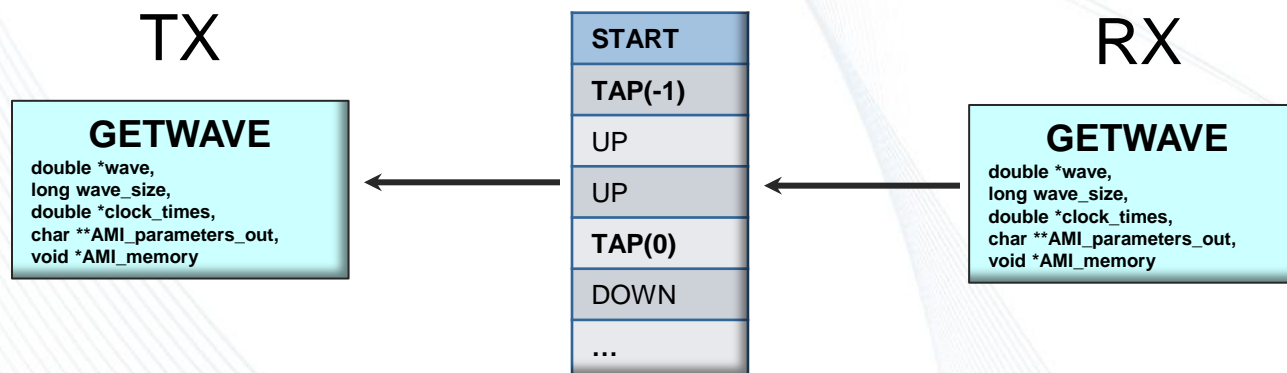
- Needed for model ***interoperability***, ensuring different vendor's models work together
- Messages will be specific to a protocol (i.e. PCIe Gen3 vs. 10GBASE-KR)

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IBIS-AMI Backchannel Results

- ## Co-optimized settings
  - Final tap coefficients for Tx and Rx
  - Eye height/width/BER for optimized channel
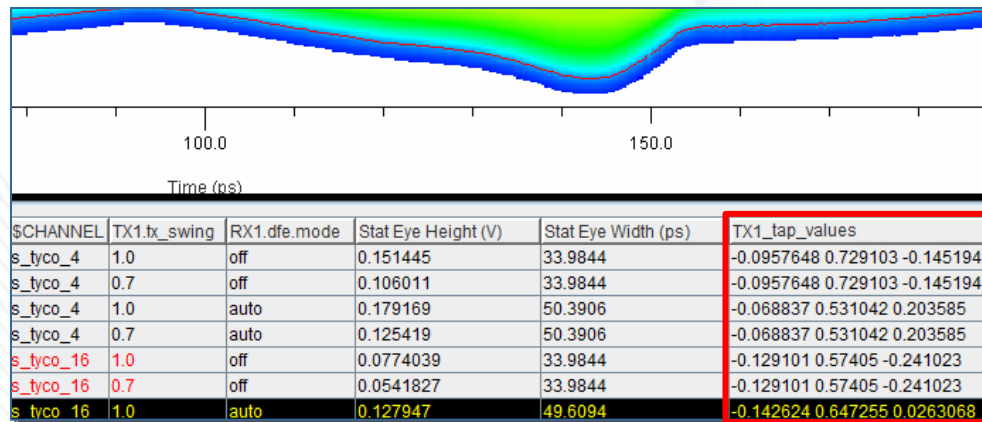
Optimized Coefficients

$CHANNEL	TX1.tx_swing	RX1.dfe.mode	Stat Eye Height (V)	Stat Eye Width (ps)	TX1_tap_values
s_tyco_4	1.0	off	0.151445	33.9844	-0.0957648 0.729103 -0.145194
s_tyco_4	0.7	off	0.106011	33.9844	-0.0957648 0.729103 -0.145194
s_tyco_4	1.0	auto	0.179169	50.3906	-0.068837 0.531042 0.203585
s_tyco_4	0.7	auto	0.125419	50.3906	-0.068837 0.531042 0.203585
s_tyco_16	1.0	off	0.0774039	33.9844	-0.129101 0.57405 -0.241023
s_tyco_16	0.7	off	0.0541827	33.9844	-0.129101 0.57405 -0.241023
s_tyco_16	1.0	auto	0.127947	49.6094	-0.142624 0.647255 0.0263068

- ## Convergence algorithm metrics
  - Figure of Merit for optimization quality
  - Time needed to equalize, tap drift, etc.

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Statistical and Time Domain Flows

- Statistical Backchannel Co-Optimization
  - Rx AMI_Init determines optimized Tx Tap coefficients and outputs them in a standardized format
  - EDA Tool reruns the Tx AMI_Init / Rx AMI_Init sequence with the updated Tx Tap coefficients

- Time-Domain Backchannel Co-Optimization
  - Rx AMI_Init output modifies the input to the first Tx AMI_Getwave call
  - Each Rx AMI_GetWave output modifies the input to the subsequent Tx AMI_GetWave call.

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Statistical Co-Optimization

- Time-Domain is like having someone scratch your back:
  - Higher, lower, left, right, lower, left, ahhh!

- Statistical is like having a back scratcher: you can get directly to the spot.
  - Quickly analyze self-optimizing performance of *many* channels.

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Who Will Use Backchannel Models?

- ## System Designers
  - Determine how well channels work with Technology (Standards-based) models
  - Determine how well channels work with specific IP

- ## IC Vendors
  - Test proposed IP against reference customer channels
  - Compete for new design wins

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IBIS-AMI Backchannel Reflector

- IBIS has set up an e-mail forum for discussing Backchannel modeling and simulation

- This forum is open to all interested parties. Non IBIS members are invited.

- The goal of this forum will be to prepare a Backchannel BIRD for submission to the IBIS Open Forum.

  - ibis-serdes-backchan@freelists.org

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Summary

- Two levels of standardization needed for IBIS-AMI

  – Communication path between models (Portability)

  – Messaging protocol (Interoperability)

- Need Statistical & Time-Domain simulation support

- Need to extend IBIS-AMI flows for Backchannel

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