AMI DLL Hook: A novel debug method for IBIS-AMI simulation

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Agenda

- Background
- DLL hook concept
- Previous hook methods in IBIS-AMI
- DLL hook implementation in AMI simulation debug
- Story sharing: a debug experience with AMI DLL hook
- Summary
Background

- When validating our IBIS-AMI models, the following problems appear:
  - Trend of batch simulation is not well-matched to silicon simulation.
  - Simulation results are different in different EDA software.

- As a model user, the following troubles are slowing down our debug progress:
  - No access to EDA or IBIS-AMI source code.
  - Limited understanding of mathematical calculation process of EDA. This may lead to improper setting during simulation.
  - Limited debug dump data from EDA or AMI model.

- AMI DLL hook is therefore introduced to speed up our debug.
Background

- Target audience:
  - IBIS-AMI model user.
  - IBIS-AMI model validator working with model provider.
  - Have basic C/C++ knowledge.
DLL hook concept

- A bundle of programming technology used to **alter the behavior** of applications / software components, by **intercepting function calls** between software components.\(^1\)

- Neither Software A nor DLL B is aware of the existence of hook C.

- Hooking has been used in software domain for a while.\(^1\)

\(^1\) https://en.wikipedia.org/wiki/Hooking
Previous hook methods in IBIS-AMI

- Xilinx has proposed “debugging hook” in *A New Methodology for Developing IBIS-AMI Models*, on DesignCon 2015.
  - It is suggested to add hooks between components *during model development phase*, to make debugging easier.
  - It is a good proposal but may require model builder’s work. As a user, we can’t add hook if the models are already there.
DLL hook implemented in AMI simulation debug

- A Hook with standard AMI interface (so it can cheat EDA).
- Call original AMI DLL inside private hook codes.

- Rename the hook dll to ami dll name, and change original dll to internal callback name
- Each dll needs an individual hook.

Standard AMI interface

Callback definitions

Private hook codes
DLL hook implemented in AMI simulation debug

- EDA calculation process before implementing AMI DLL hook
DLL hook implemented in AMI simulation debug

- EDA calculation process **after** implementing AMI DLL hook
- Note: Simulation will be slower with hook injected.

EDA Tool

- Start
- Calculate IL & XTK
- Impulse Response
- AMI Init (Mainly for Statistical Simulation)
  - AMI_Init
  - Dump & Modify
  - Data
  - Impulse Response Matrix 1
  - AMI_Init (AMI_Init)
  - Postprocessing Response
  - Impulse Response Matrix 2

AMI Init

- AMI_Init
- Dump & Modify
- Data
- Impulse Response Matrix 1
- AMI_Init (AMI_Init)
- Postprocessing Response
- Impulse Response Matrix 2

AMI GetWave

- AMI_Init
- Dump & Modify
- Data
- Impulse Response Matrix 1
- AMI_Init (AMI_Init)
- Postprocessing Response
- Impulse Response Matrix 2

Simulation Done?

- Yes
- No

EDA Calculation Process

- After implementing AMI DLL hook

Simulation

- AMI Init (Mainly for Statistical Simulation)
  - AMI_Init
  - Dump & Modify
  - Data
  - Impulse Response Matrix 1
- AMI_Init (AMI_Init)
- Postprocessing Response
- Impulse Response Matrix 2

AMI GetWave (Time Domain Simulation)

- AMI_Init
- Dump & Modify
- Data
- Impulse Response Matrix 1
- AMI_Init (AMI_Init)
- Postprocessing Response
- Impulse Response Matrix 2

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EDA calculation process

- DLL hook implementing in AMI simulation debug
- Note: Simulation will be slower with hook injected.

RX IBIS Model
TX IBIS Model
RX AMI Hook
TX AMI Hook

EDA Tool

- Start
- Calculate IL & XTK Impulse Response
- Call Tx AMI Model AMI_Init()
- Postprocessing Response
- Call Rx AMI Model AMI_Init()
- AMI_Init Done
- Generate Digital Stimulus Call Tx AMI Model AMI_GetWave()
- Call Rx AMI Model AMI_GetWave()
- Waveform Calculation
- Wave Matrix 1
- AMI_Init
- Stop

Yes
No

Simulation Done?

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DLL hook implemented in AMI simulation debug

- EDA calculation process **after** implementing AMI DLL hook
- The much bigger problem (results mismatch) will be divided into smaller problems, thus helped debug.
- Example is AMI_Init. The processing of AMI_Init is divided into 5 parts (1-5) as shown.

Note:
In time domain simulation, although AMI_Init steps 2-5 are not considered, it will still process and provide important information for debug. Details will be shown in upcoming section.

We can also implement hook into AMI_Getwave, but we won’t dig into it today.
Story sharing:
a debug experience with AMI DLL hook
A debug experience with AMI DLL hook

- **The problems:**
  - Trend of batch simulation is not well-matched to silicon simulation.
  - Simulation results are different in different EDA software.

- **The questions:**
  - Is there any not-aligned setting between silicon simulation and our deck?
  - Is there any not-aligned / wrong setting between EDAs?
  - Is there any bug in AMI model?
  - Is there any bug in either EDA?
1. Passive channel alignment

- **Check step response:**
  - **Hook is not needed.** Both EDAs can provide step response dump.
  - *Step responses are very similar*
1. Passive channel alignment

- Check step response:
  - Hook is not needed. Both EDAs can provide step response dump.
  - *Step responses are very similar
  - *Xtalk channels are also similar (*but not exactly same)
1. Passive channel alignment

- **Check impulse response:**
  - **Hook is needed.** Only one of the two EDAs can provide impulse response dump.
  - Difference between EDAs is significant when looking at impulse response. This is later found *caused by improper default settings in EDA2*.
  - After fixing the settings in EDA2, both EDAs have almost same impulse.
1. Passive channel alignment

- What has hook helped?
  
  • Dumped step responses, directly from EDA, are not that different.
  
  • By hooking at TX IBIS AMI input side and dumping impulse response, we divided the big problem (results not matching) into a small problem (input impulse response differed from same passive channel)
  
  • Solving this small problem is much easier, that it doesn’t need long time run and it limited the range of affected settings.
2. AMI input problem

- Check TX output impulse response:
  - **Hook is needed.** Neither EDA could provide this dump.
  - AMI input in one of the EDAs is suspicious and later confirmed a problem.
  - This is due to our batch run script will provide formula with variables to the AMI input. **EDA2 is not dealing with formulas in AMI_parameters_in section.**
2. AMI input problem

- Check TX output impulse response:
  - After fixing the AMI_parameters_in, both EDAs got same impulse at TX out.

- What has hook helped?
  - It is hard to imagine this issue without hook dumped data
  - It also limited the problem in the range of after TX input but before TX output, so the problem is small and easy to find root cause.
3. Different behaviors in dealing with Xtalk channels

- Found by AMI_Init dump.
  - EDA1: AMI_Init with 0 aggressors. Xtalk channels are treated separately. (Another AMI_init with 1 aggressor)
  - EDA2: AMI_Init with real aggressors.
3. Different behaviors in dealing with Xtalk channels

- What has hook helped?
  - We learned the xtalk special processing in EDA1 and may introduce more consideration in future projects.

- An open question:
  - Which way is more common in modern EDAs?
  - What is the recommendation from IBIS open forum?
Summary

- AMI DLL hook can help IBIS-AMI simulation debug by:
  - Split the big problem into multiple checkpoints and thus multiple smaller problems. Each of the small problem is much easier to solve.
  - Provide much more extra information to SI engineer who don't have access to model or software source codes.

- AMI DLL hook has helped and provided 3 significant helps in one of our projects as story sharing suggested.
Open discussion to IBIS Open Forum

- Is it possible to EDA software to provide all IBIS-AMI API dumps to general users? Maybe open it with some internal debug environment variable, etc.
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