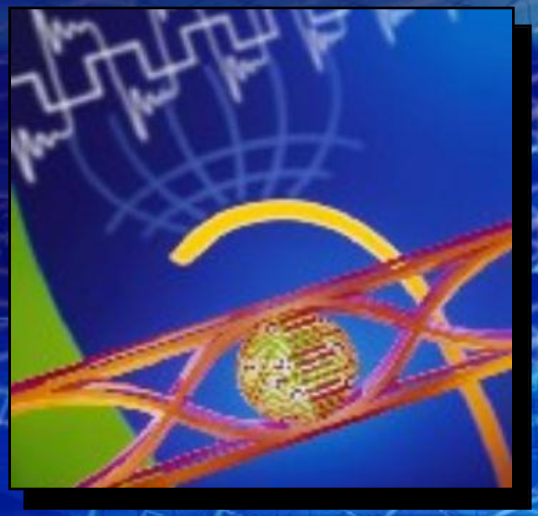
How Did We Get Here and How Do We Go On From Here?



IBIS Summit, DesignCon,
February 2, 2012
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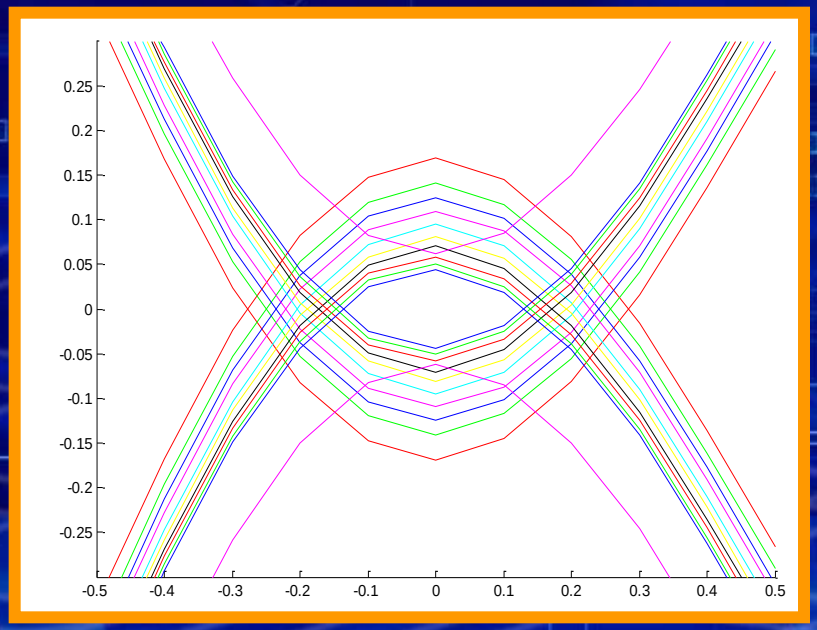

Arpad Muranyi

Mentor Graphics®

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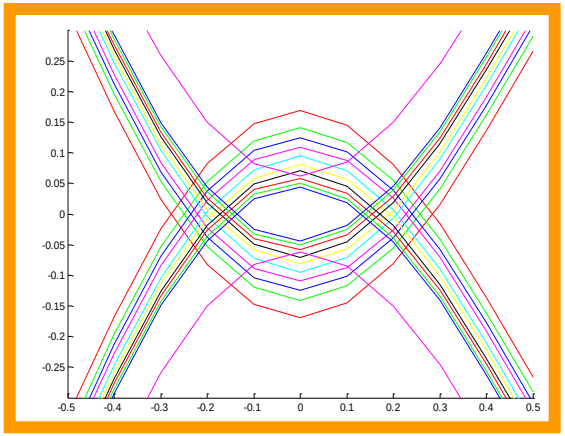

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1. **Motivation and purpose**
2. **The three biggest topics**
3. **Unlimited corners**
4. **Fixed topology vs. general purpose models**
5. **IBIS Hierarchy related problems**
6. **[External Circuit] and BIRD 145**

Motivation and purpose

- **The IBIS-ATM Task Group is now evaluating the various analog modeling BIRDs**
  - **BIRD 122 and its variants by SiSoft**
  - **BIRD 116, 117, 118, 129 for buffers and BIRD 125 for packages by Mentor**
  - **BIRD 144, 145 by Cadence**
- **Major aspects of these proposals involve [External Model] and/or [External Circuit]**
  - **adding IBIS-ISS as a new language option (BIRD 116, 122)**
  - **adding Touchstone as a new language option (BIRD 144)**
  - **allowing [Model] to be cascaded with [External Circuit] (BIRD 145)**
- **Some proposals deviate from the "IBIS tradition" or "philosophy"**
  - **are these deviations deliberate and/or necessary?**
  - **can we achieve the same results using more consistent solutions with IBIS history?**
- **Let's look at the "big picture" to guide the direction of our decisions**

The three biggest topics

- **Desire to extend the traditional Typ/Min/Max corners to unlimited corners**
  - **BIRD 124 (Dependency Table) proposes an unlimited corners solution for AMI purposes, and SiSoft (Walter) is vocal about needing more than three corners for legacy IBIS models**
  - **BIRD 144 proposes "User Defined Corner" for [External Model] and [External Circuit]**
  - **presentation from 1999(!) "*Thoughts on Equations in IBIS Models*" (pg. 8, 10, 15, 17): http://www.eda.org/ibis/summits/jun99/muranyi.zip**
- **General purpose vs. fixed topology modeling**
  - **using IBIS-ISS subcircuits with [External Model] provides a general purpose (LTI) solution**
  - **predefined circuit templates or direct connection to Touchstone files are proposed as a shorthand notation alternate to the IBIS-ISS approach to reduce "clutter" (eliminating unnecessary IBIS-ISS file duplicates and text repetitions in the .ibs file)**
- **IBIS file hierarchy related problems**
  - **currently, IBIS-AMI models are referenced (instantiated) by [Model]s in the .ibs file**
  - **variants of BIRD 122 propose referencing (instantiating) analog models from the .ami file**
  - **currently, package models are referenced by the IBIS [Component]**
  - **variants of BIRD 122 propose referencing (instantiating) packages from the [Model]**

The IBIS corners

- **Why does IBIS have three corners only, if devices operate under a continuous range of conditions?**
  - **SPICE circuit elements are associated with device manufacturing process models which usually contain a few specific sets of manufacturing conditions (fast/slow, maybe typical)**
  - **note that all other simulation parameters in SPICE can be swept continuously (electrical parameters, such as R, L, C, voltage, temperature, etc…, and even device geometry)**
  - **in the early 90's, most of the SI work consisted of a few best/worst case simulations, so putting Typ/Min/Max into the IBIS specification seemed sufficient initially**
  - **in the mid 90's SI simulations began to explode with simulation sweeps, Monte Carlo analysis, Design of Experiments (DoE), etc…**
  - **compensated and multi-tap buffers wiped out the concept of Typ/Min/Max and Best/Worst case and even more simulations were needed to find a solution space**
  - **equation based models could have made things easier, but the presentation mentioned on the previous slide did not result in any actions**

The Corner subparameter of [External ***]

- **The three "Corner"-s of [External Model] or [External Circuit] can be used in two different ways**
  - **if the file(s) referenced in the "Corner" subparameter contain(s) "hard coded models", the three "Corner" entries can be used to pick one of the three models**
  - **if a file referenced in the "Corner" subparameter contains a "parameterized model", there is really no need for the three "Corner" entries, because the model parameters can implement the corner behavior changes**
  - **this was already known when BIRD 75 was written**
- **Parameterized models can support an unlimited number of corners or even the concept of "continuous corner"**
  - **the *-AMS languages already support this**
  - **the IBIS-ISS specification also supports this**
  - **string parameters are available in all of these languages, so parameterized Touchstone file names are also supported**

What is missing for unlimited corners?

- **Currently, an .ibs file can only have a list of parameter names for [External Model] or [External Circuit], no values can be provided**
  - **the idea was that the EDA tool will pop up a dialog for the user with a parameter list, so they can type in all the values for each parameter**
  - **this is cumbersome for the user because they have to find the data from other documentation and do a lot of manual typing**
  - **when [External Model] and [External Circuit] was added to the specification, this was the simplest approach we could implement, but improvements were anticipated**
- **A parameter assignment syntax in [External Model] and [External Circuit] would come very handy**
  - **BIRD 118.2 proposes a solution for this but it has a few small limitations in this context**
  - **parameter values are either a single value in the .ibs file or a reference to an .ami file**
  - **the tree syntax of .ami files provides more capabilities (List, Range, etc…) but the .ami file can only be found from the [Algorithmic Model] keyword, which may not always be present**
  - **changing the BIRD 118.2 syntax from:** `AMIfile(ParamName)` **to:** `FileName.ext(ParamName)` **would allow any file to be used as long as they contain tree formatted parameter data**
- **This syntax could be extended easily to legacy IBIS**

Example

- **Imagine the example on the bottom of pg. 36 in the IBIS v5.0 specification to look like this:**

```
[Model] Clockbuffer
Model_type I/O
Polarity Non-Inverting
Enable Active-High
Vinl = ParameterFileName.txt(Vinl)     | Input logic "low" DC voltage, if any
Vinh = ParameterFileName.txt(Vinh)     | Input logic "high" DC voltage, if any
Vmeas = ParameterFileName.txt(Vmeas)   | Reference voltage for timing measurements
Cref = ParameterFileName.txt(Cref)     | Timing specification test load capacitance value
Rref = ParameterFileName.txt(Rref)     | Timing specification test load resistance value
Vref = ParameterFileName.txt(Vref)     | Timing specification test load voltage
| variable  value
C_comp              ParameterFileName.txt(C_comp)
C_comp_pullup       ParameterFileName.txt(C_comp_pullup)       | These four can be
C_comp_pulldown     ParameterFileName.txt(C_comp_pulldown)     | used instead of
C_comp_power_clamp  ParameterFileName.txt(C_comp_power_clamp)  | C_comp
C_comp_gnd_clamp    ParameterFileName.txt(C_comp_gnd_clamp)
```

- **if the file contains Format List, Range or similar parameter types, we have unlimited corners**
- **if the file also contains a Dependency Table, various parameters can be associated to track each other (or to allow only certain combinations)**
- **this would also work for I-V and V-t tables, since we do have a Format Table in the tree syntax**
- **the model maker may associate a parameter file per [Model], per parameter, per [Component], or even per multiple .ibs files, it is completely their choice...**

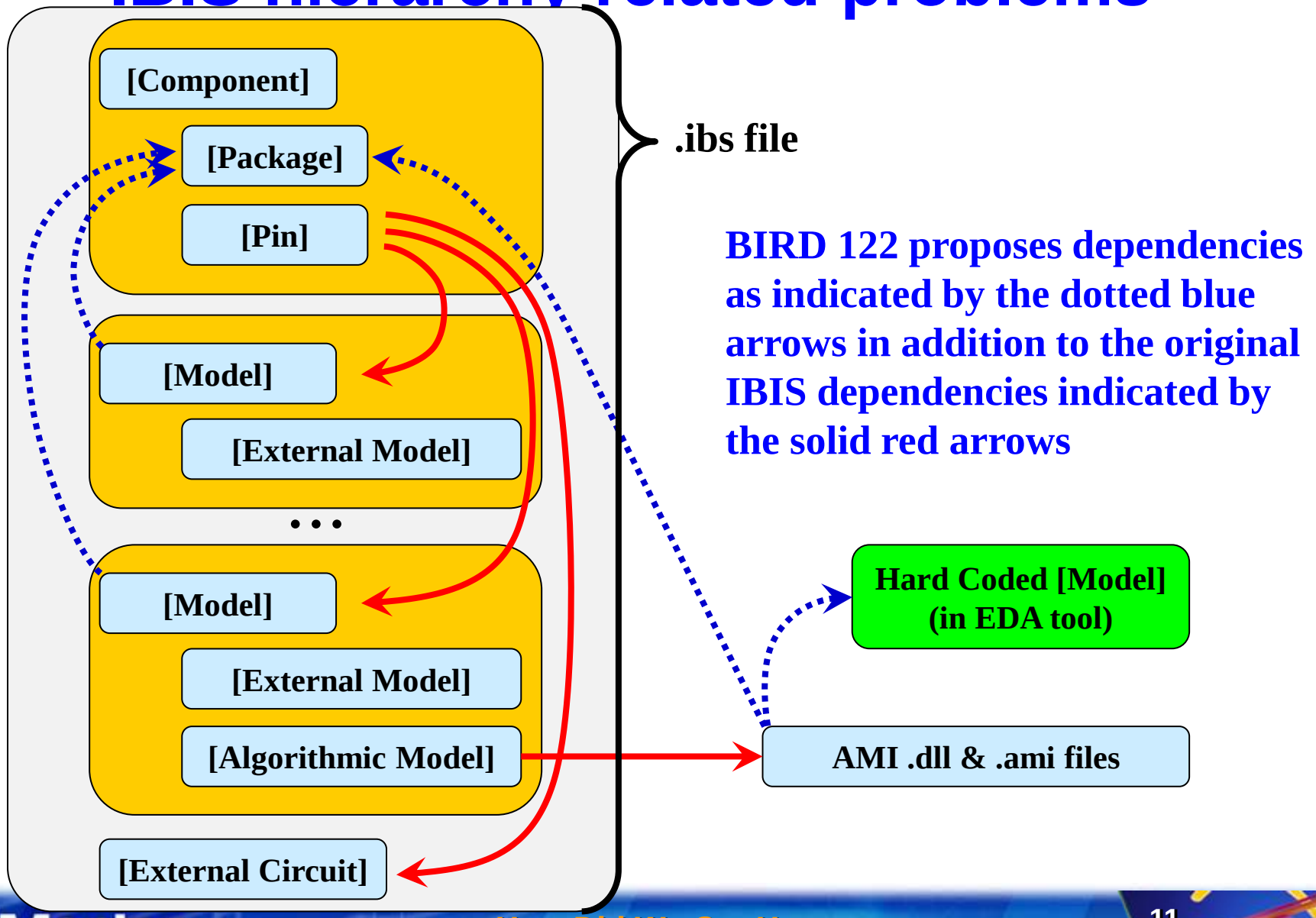
General purpose vs. fixed topology

- Fixed topology (canned, or hard coded models) are a predefined subset of the subcircuit based solution
- No technical advantages over the general solution
  - why not just go with the general purpose approach then?
  - or, is the fixed topology solution sufficient by itself?
  - the fixed topology approach might require occasional updates in the IBIS specification
  - no specification updates would be needed for the general purpose approach
- So why do we have such a heated debate over them?
  - fixed topology approach may reduce text repetition in the .ibs file under [External Model]
  - may eliminate unnecessary IBIS-ISS subcircuit file repetitions (efficient)
  - simpler syntax may make the model maker's life easier
  - may improve EDA tool performance for special cases
  - increases the size and complexity of the IBIS specification
  - the IBIS parser and EDA tool implementations may become more expensive
  - the increased complexity in the specification may confuse model makers

AMI vs. Touchstone fixed topology models

- **The fixed topology models proposed in BIRD 122 are strictly for use in AMI simulations**
  - legacy IBIS modeling does not benefit from these, have no access to these models
- **Direct support of Touchstone files (BIRD 144) is available for legacy and AMI simulations**
  - the S-element is connected in a predefined way to the ports of [External ***]
  - no other circuit elements can be supplied
  - i.e. this is still a fixed topology approach
  - User Defined Corners could be implemented by parameterization (BIRD 118.x)
- **Both approaches are a subset of the IBIS-ISS wrapper approach (BIRD 116-118)**
  - while the fixed topology models have benefits, they also have negative side effects
  - need to have proof that we can't live without fixed topology models before adding them to the specification

IBIS hierarchy related problems



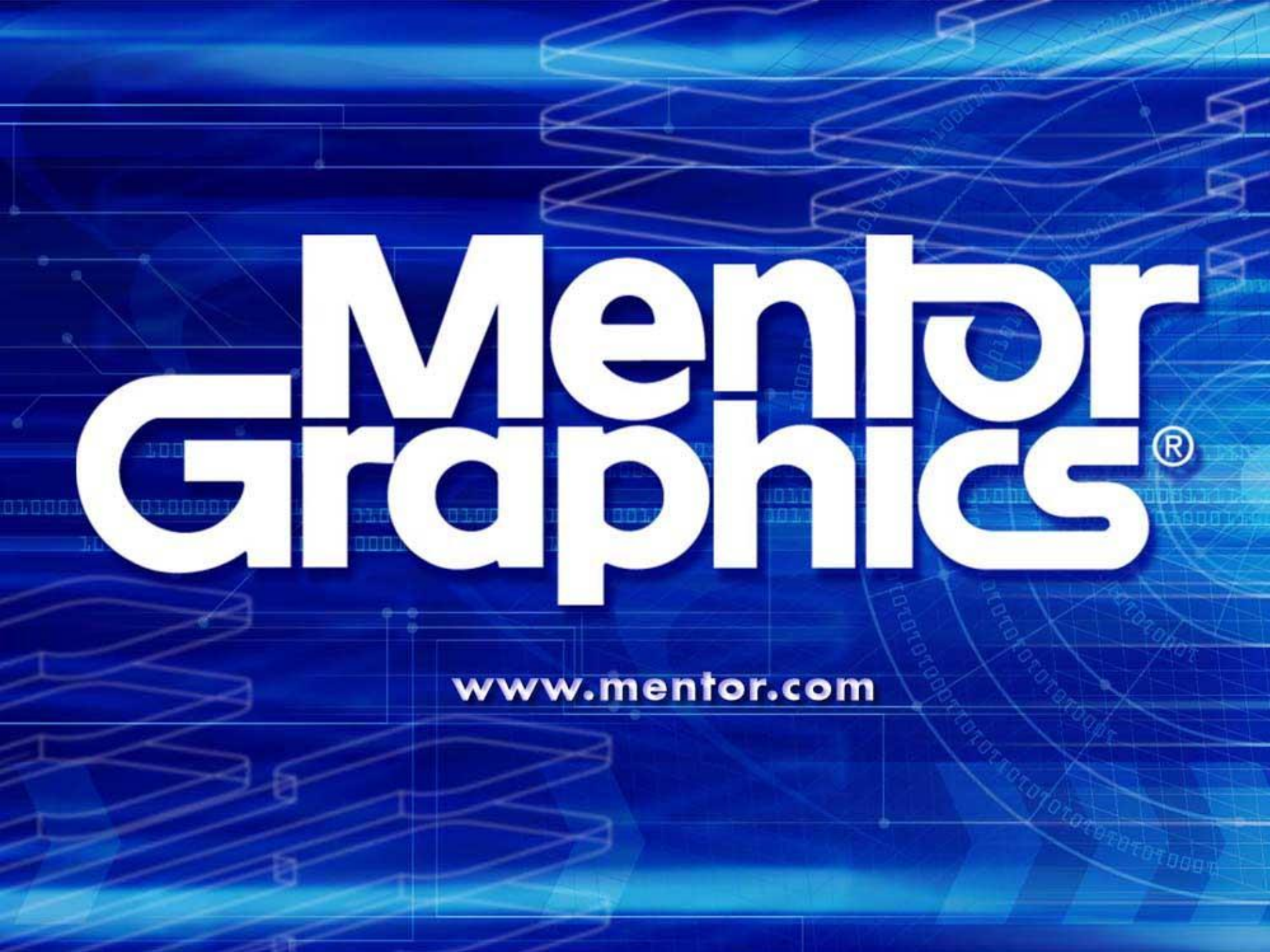
BIRD 122 proposes dependencies as indicated by the dotted blue arrows in addition to the original IBIS dependencies indicated by the solid red arrows

A note on [External Circuit] and BIRD 145

- **[External Circuit] was targeted to be a replacement for [Model]**
  - it may have any number of power supply terminals
  - it may have any number of analog or digital signal terminals
  - it may contain passive (interconnect) or active (buffer) models
  - multiple [External Circuit] may be cascaded together (to model on die interconnect and buffer models in separate blocks)
- **[External Model] was targeted to be a replacement for the internals of [Model]**
  - connectivity limited to the connectivity of [Model]
  - table based [Model] algorithms may be replaced by any other modeling algorithm
- **It was assumed that placing an [External Circuit] between a [Model] and the pad will not be needed**
  - however, buffer modeling in [External Circuit] didn't take off
  - on-die interconnect modeling could be done well with [External Circuit] and IBIS-ISS
- **BIRD 145 seems to be a useful proposal to consider**

Conclusions

- **A small change in BIRD 118.2 could give the entire IBIS specification unlimited corner capabilities**
  - **this new feature would not break any existing models**
  - **the syntax change is relatively small and easy but might involve a lot of editorial work to cover the entire IBIS specification**
- **BIRD 133.1 "*Model Corner C_comp*" not needed**
  - **the association of various modeling parameters can be addressed by the tree syntax**
- **IBIS got burned for its rigidity many times, let's not continue down that path**
  - **seems that until proven otherwise, we can do without the fixed topologies proposed by**
    - **BIRD 144.1 "*Add Touchstone to [External Model] and [External Circuit] as a Supported Language*"**
    - **portions of the proposals found in BIRD 122**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