



iCyPhy



# Freedom from Choice and the Power of Models

*In Honor of Alberto Sangiovanni-Vincentelli*

*Edward A. Lee*

**UC Berkeley**

*Keynote, International Symposium on Physical Design (IPSN)  
San Francisco, CA, April 16, 2019*



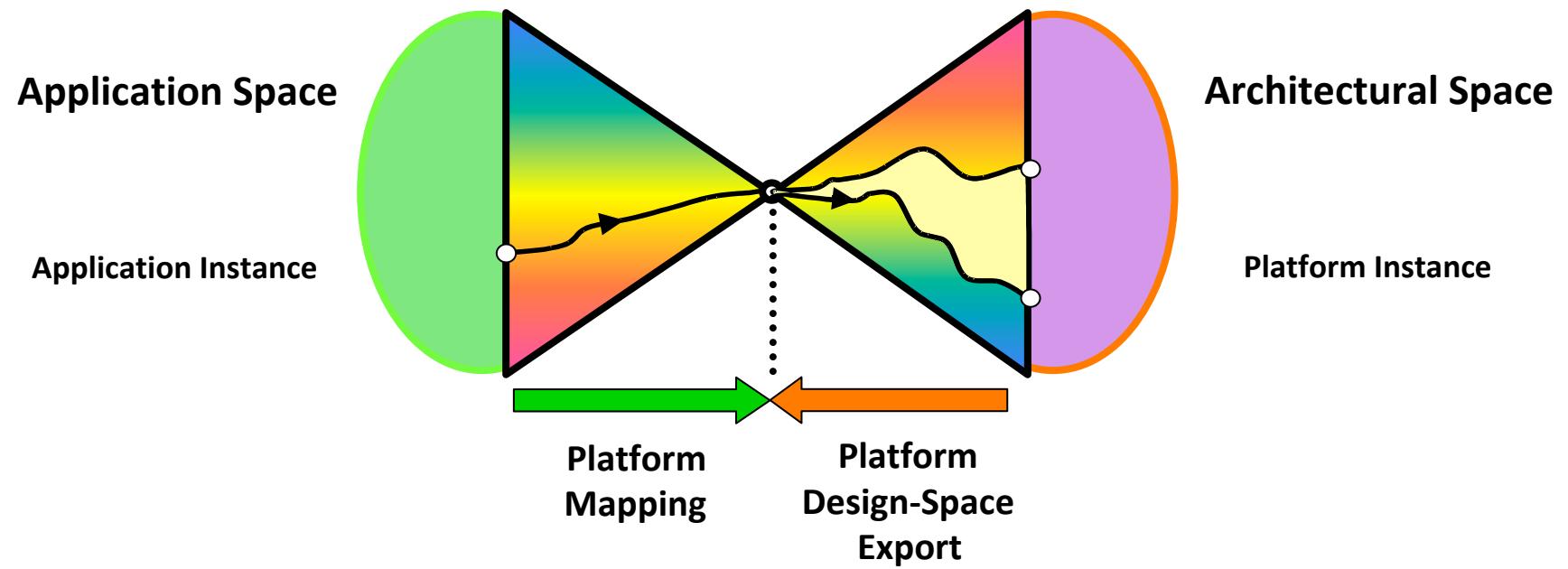
**University of California at Berkeley**

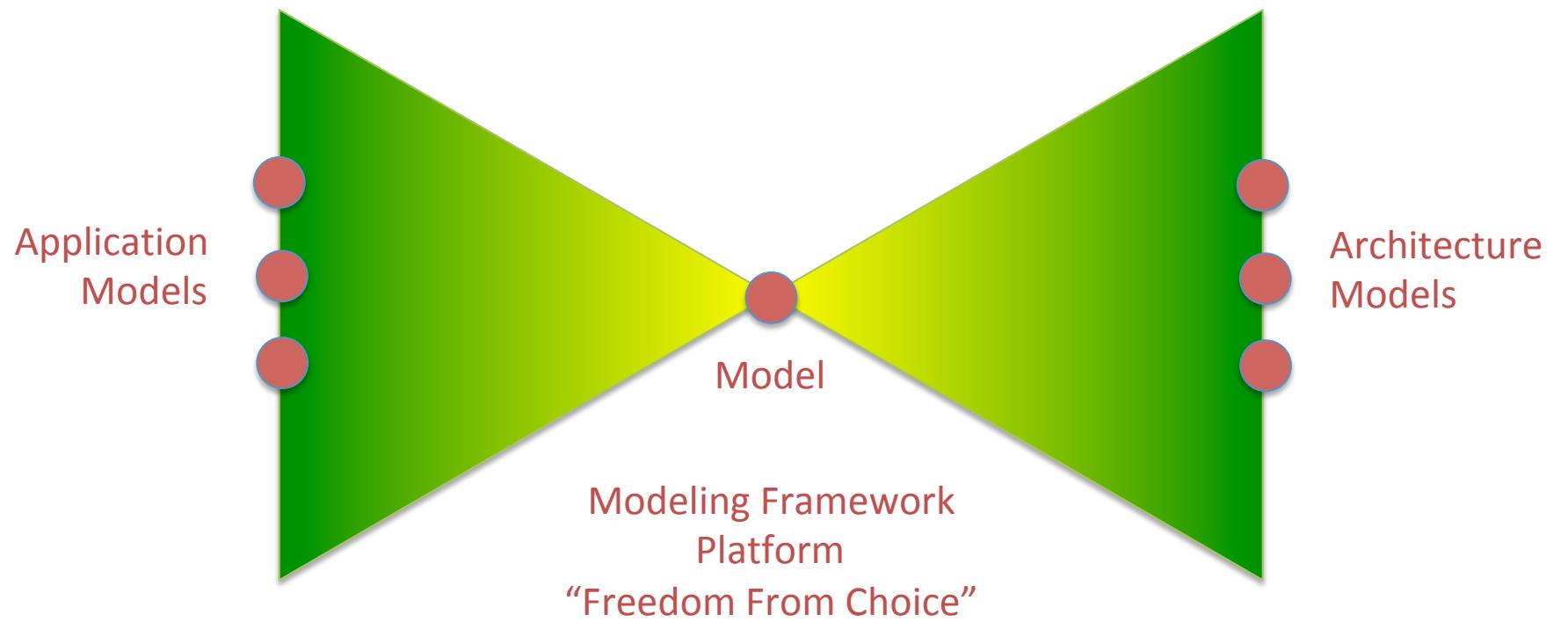


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# Platform-Based Design





If this is not clear to you...

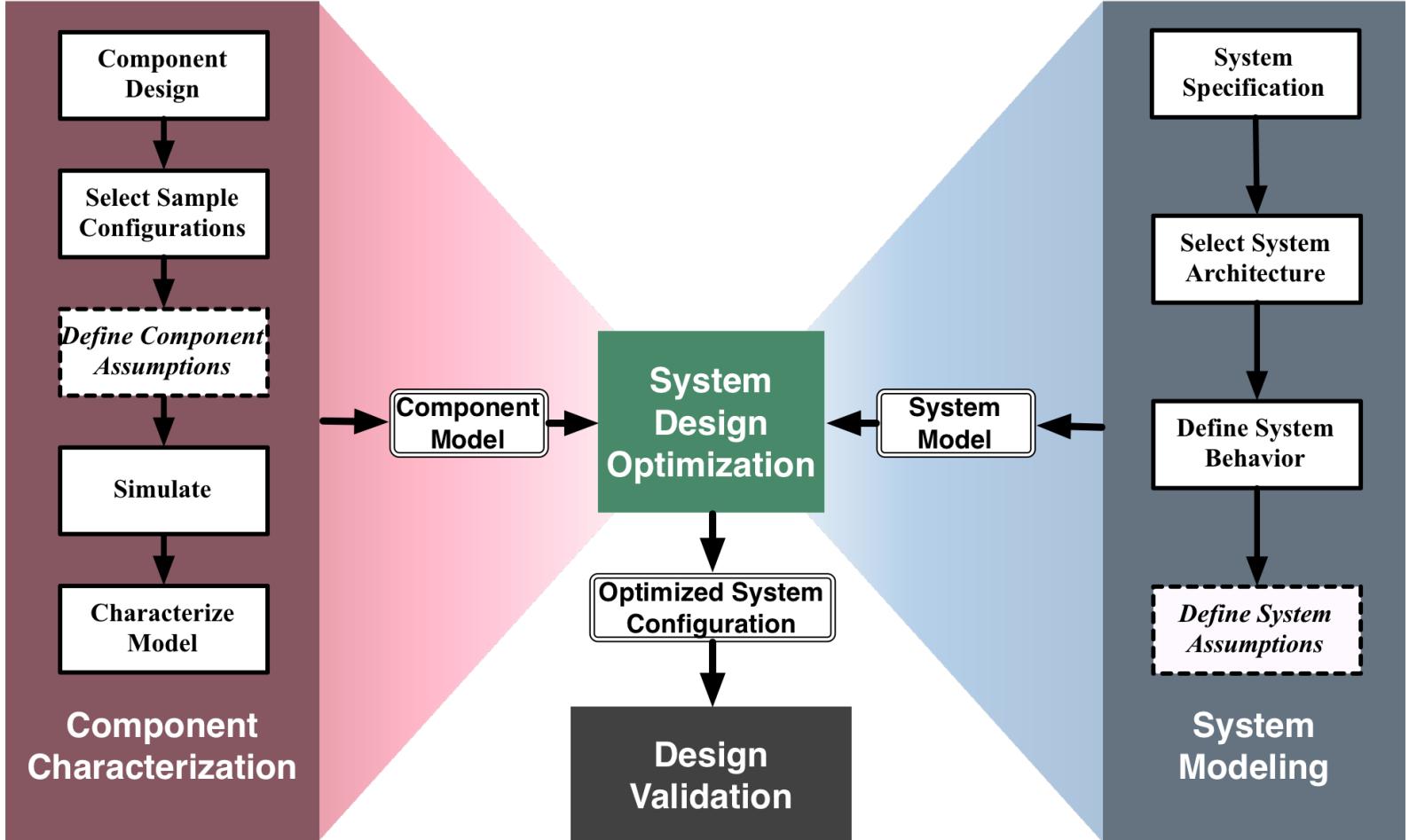
O ye possessed of sturdy intellects,  
observe the teaching that is hidden here  
beneath the veil of verses so obscure.

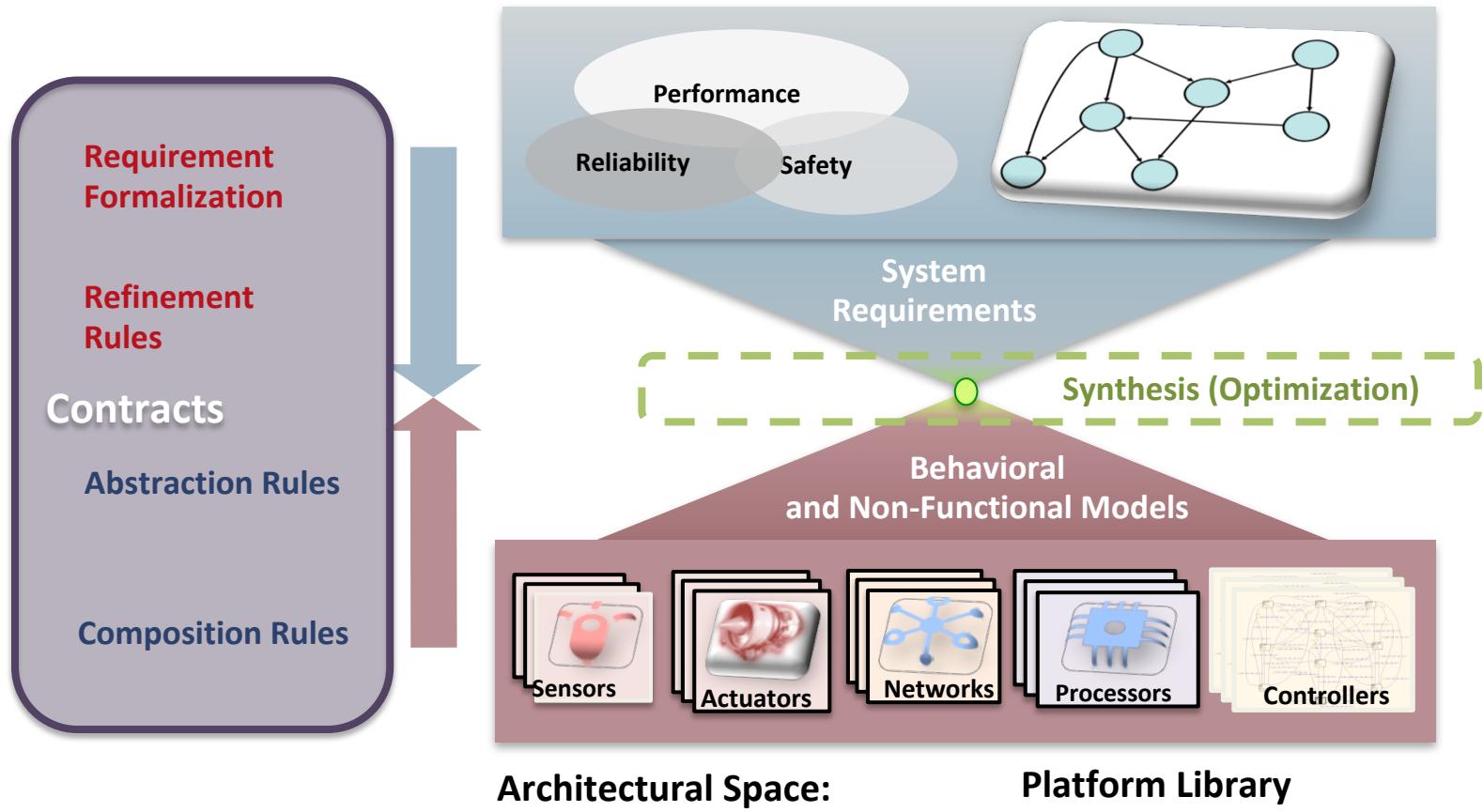
*Dante*

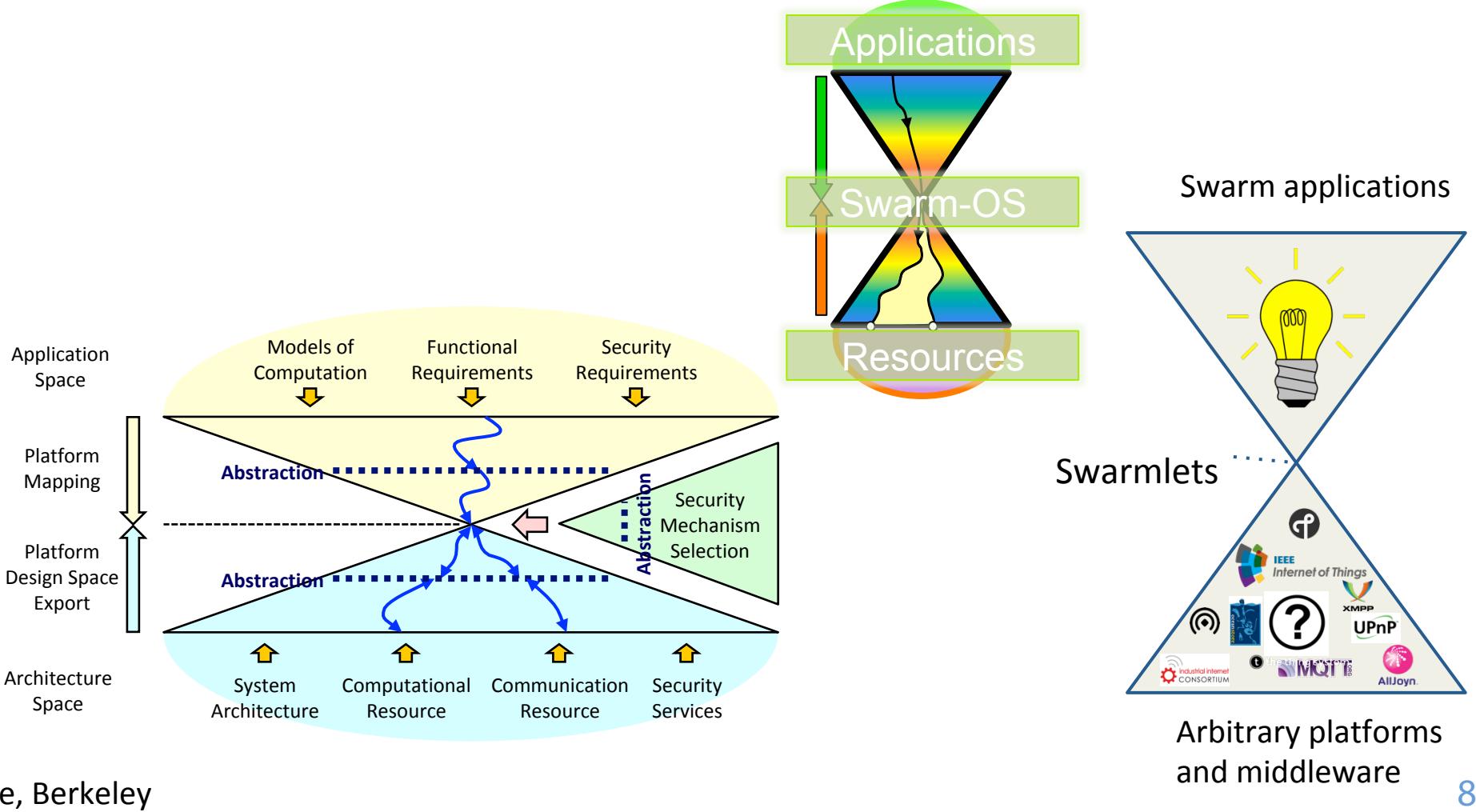
*Divine Comedy, Inferno, Canto 9*

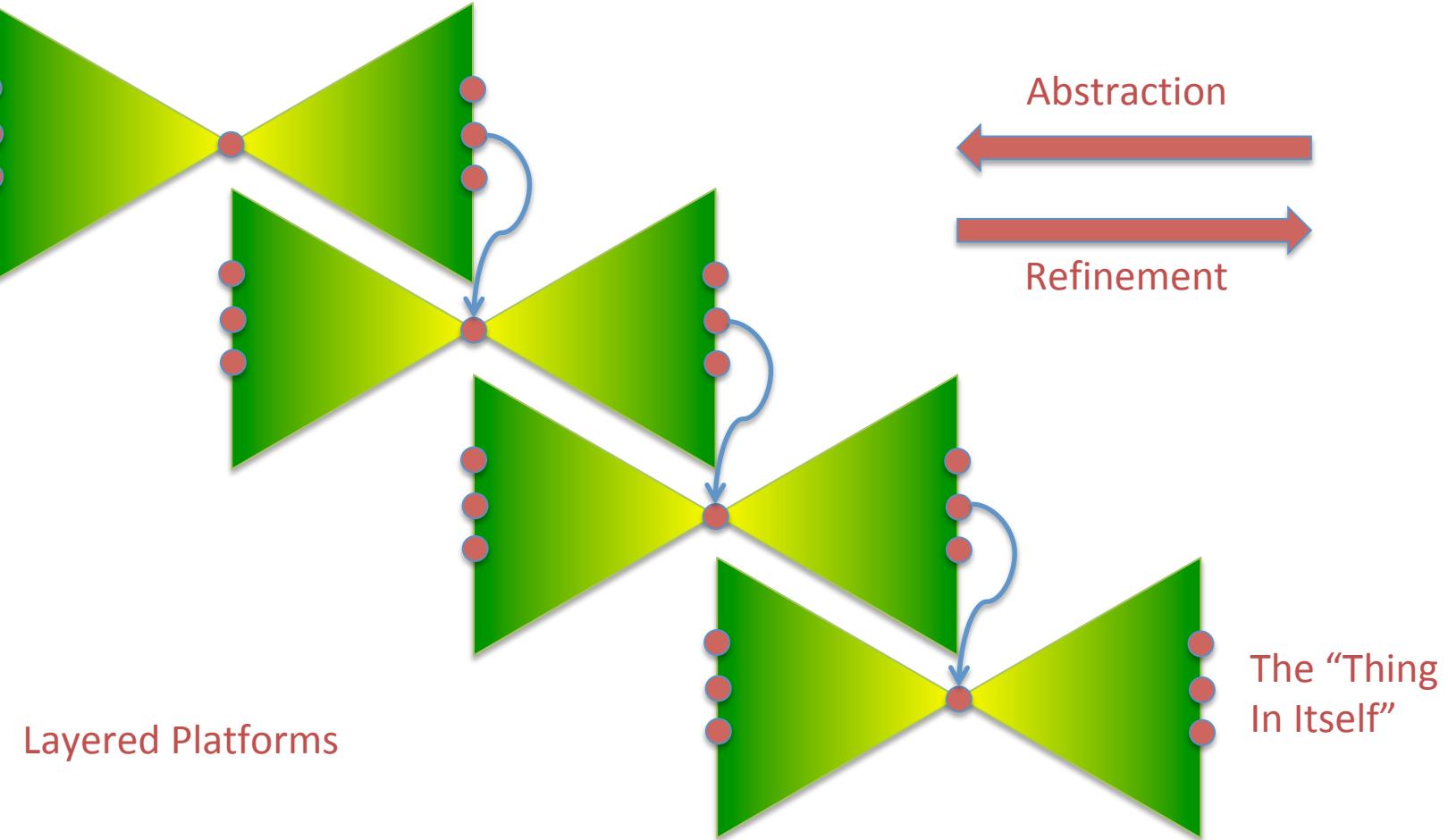
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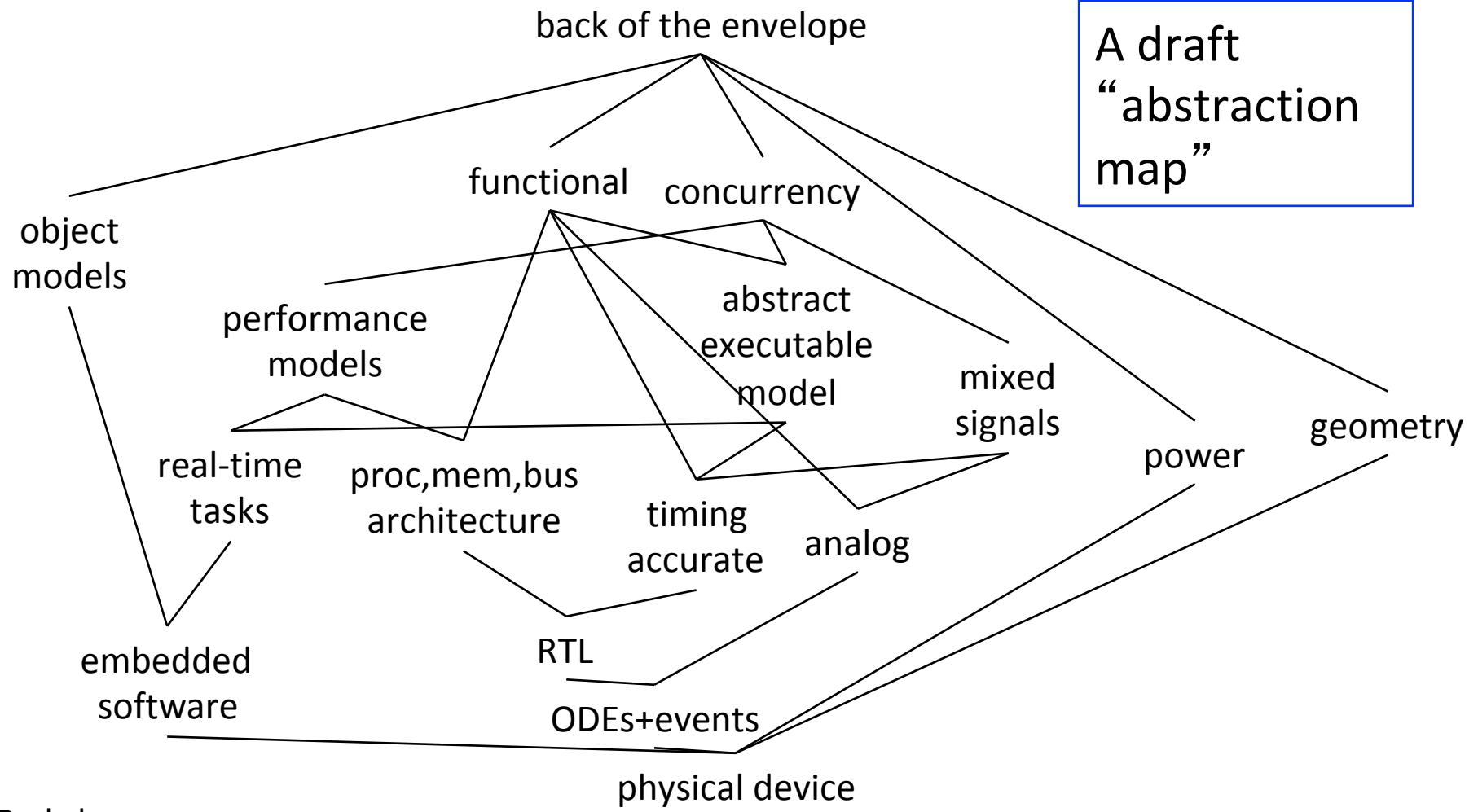




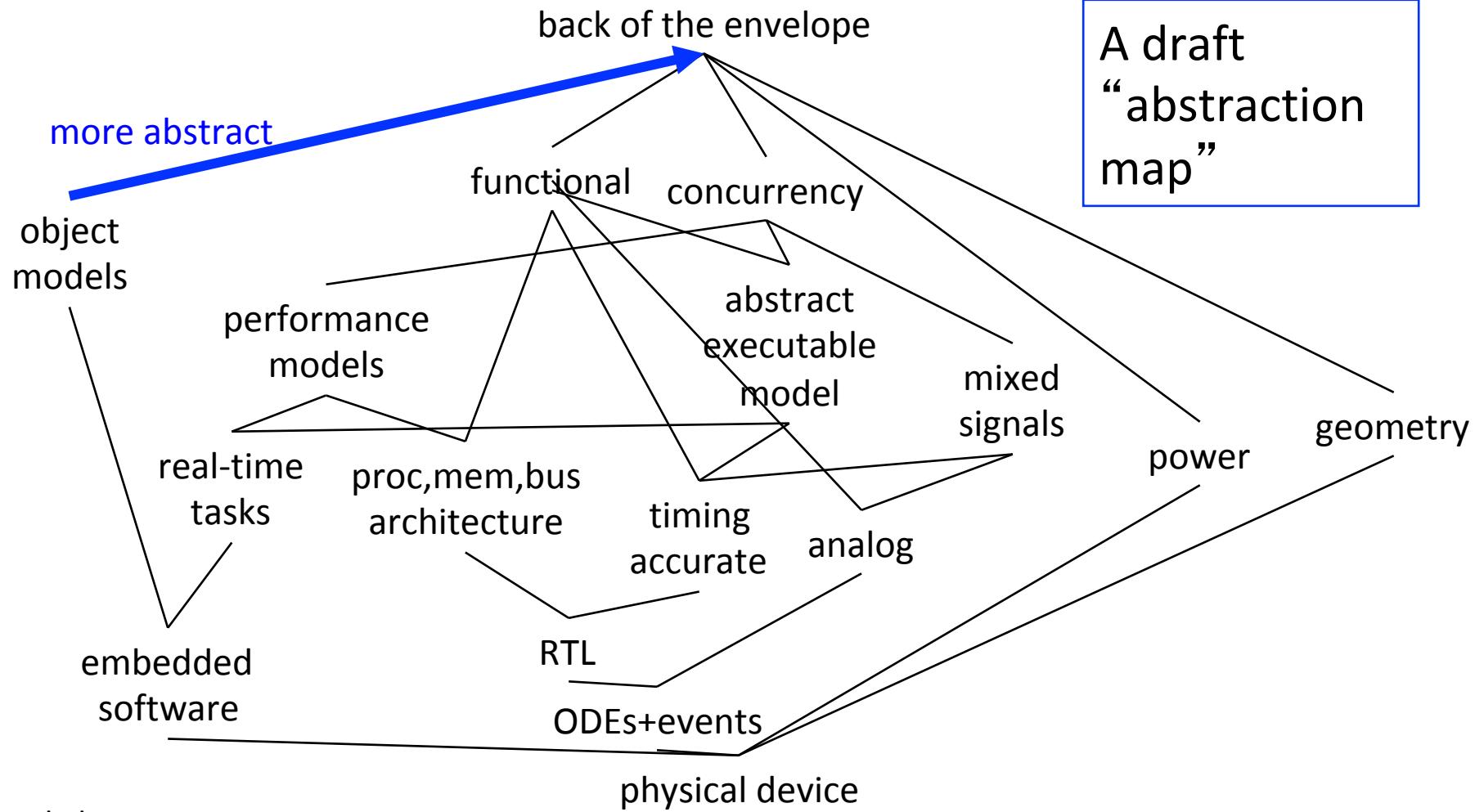




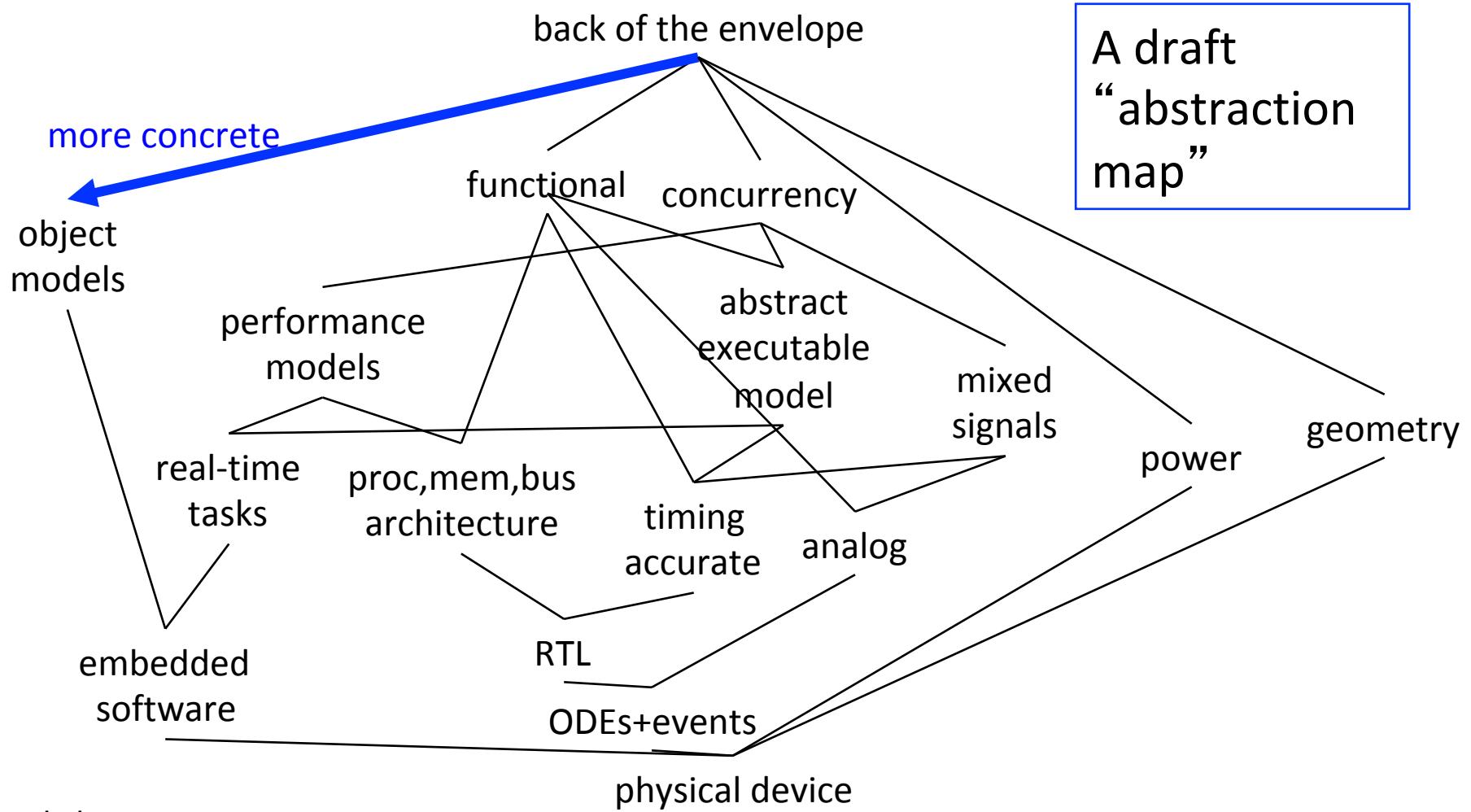
A draft  
“abstraction  
map”



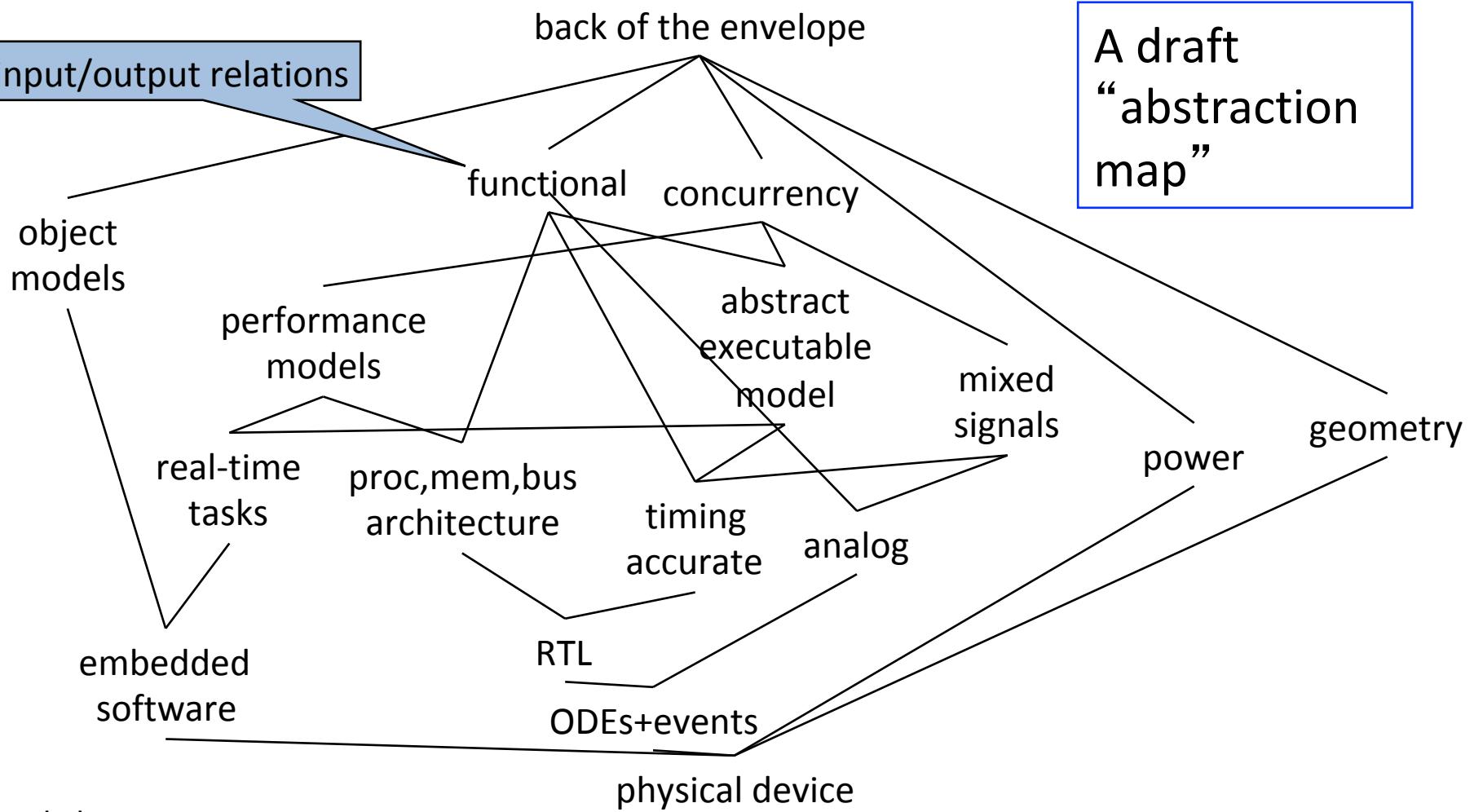
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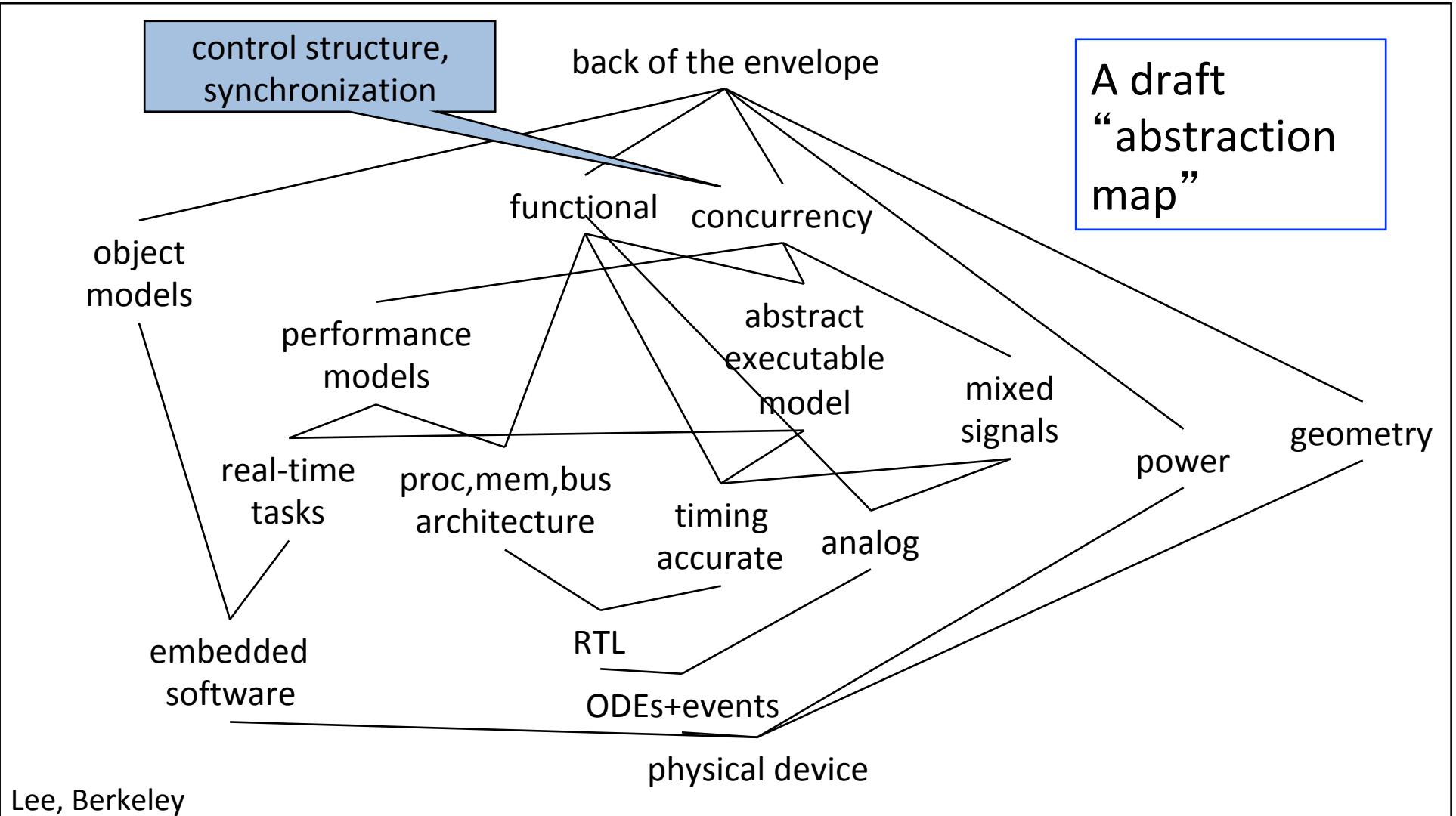


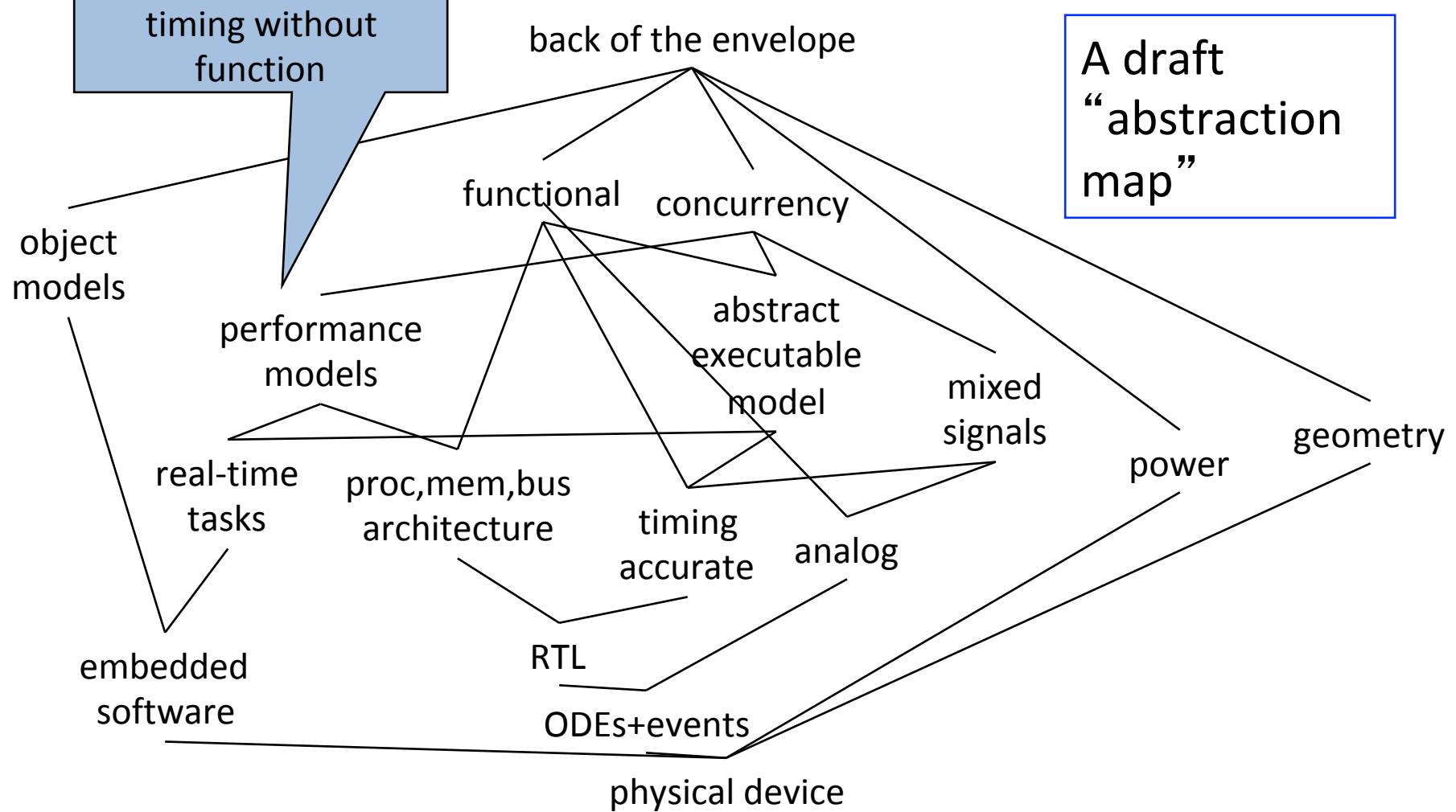
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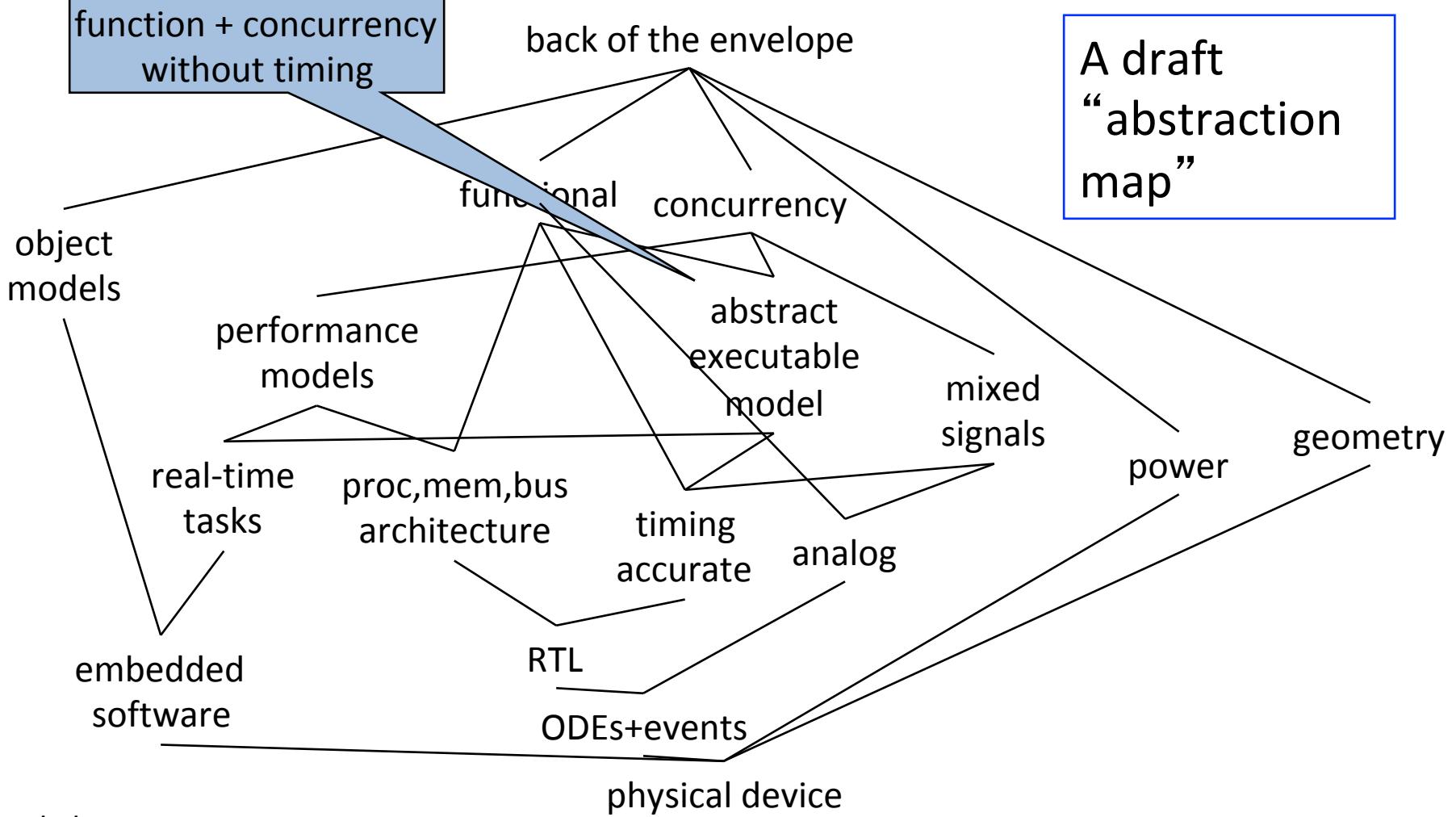


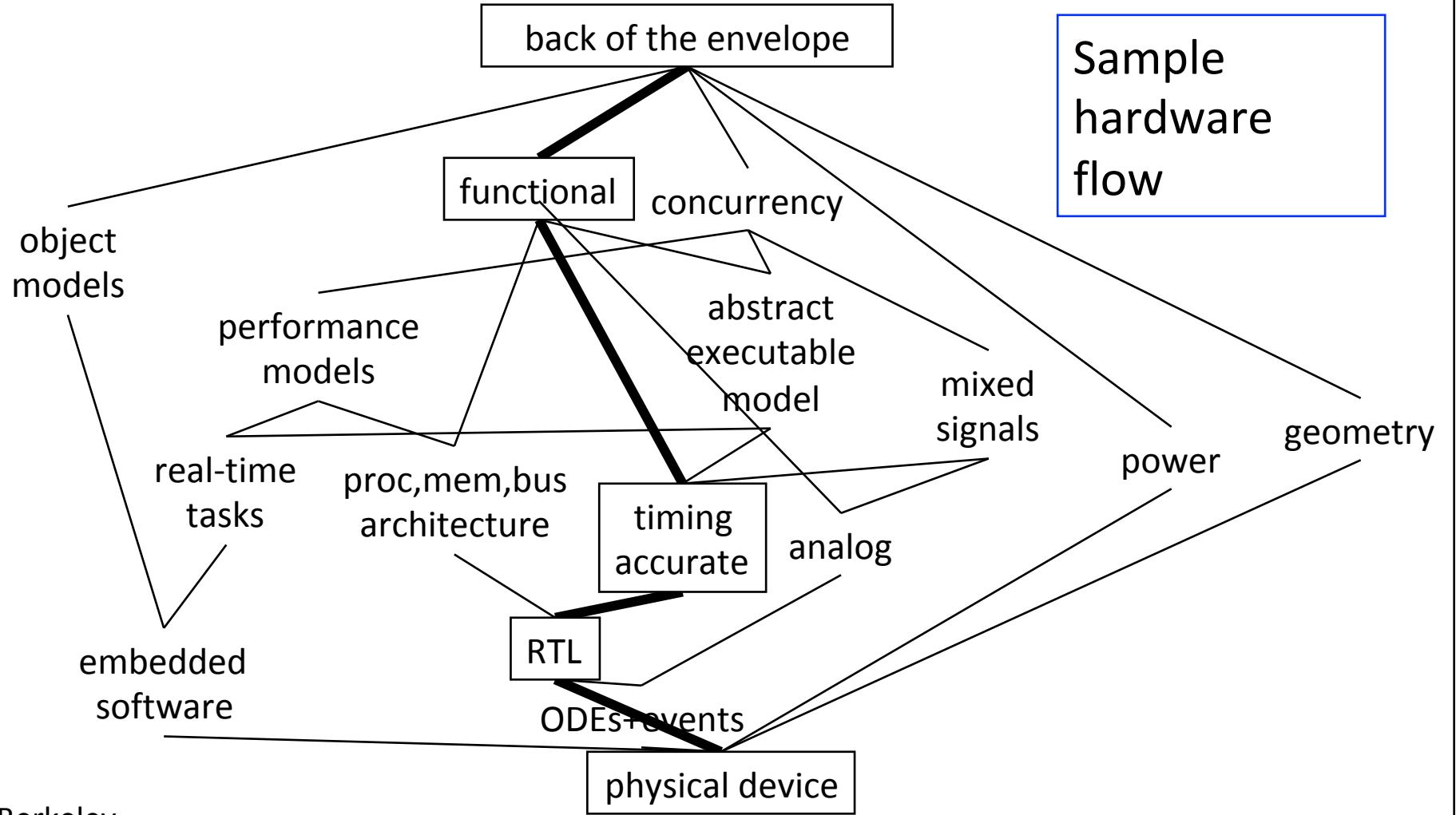
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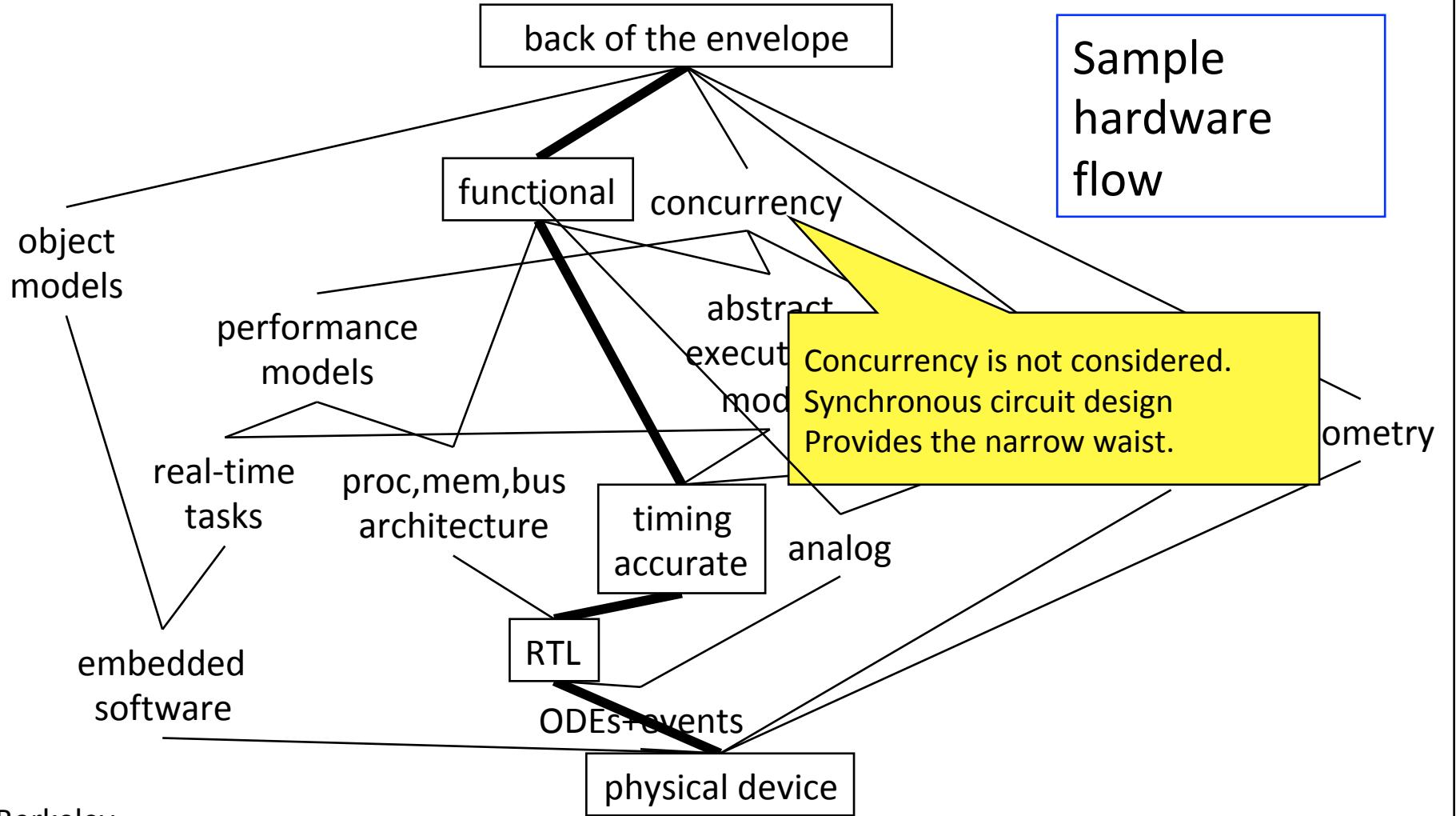


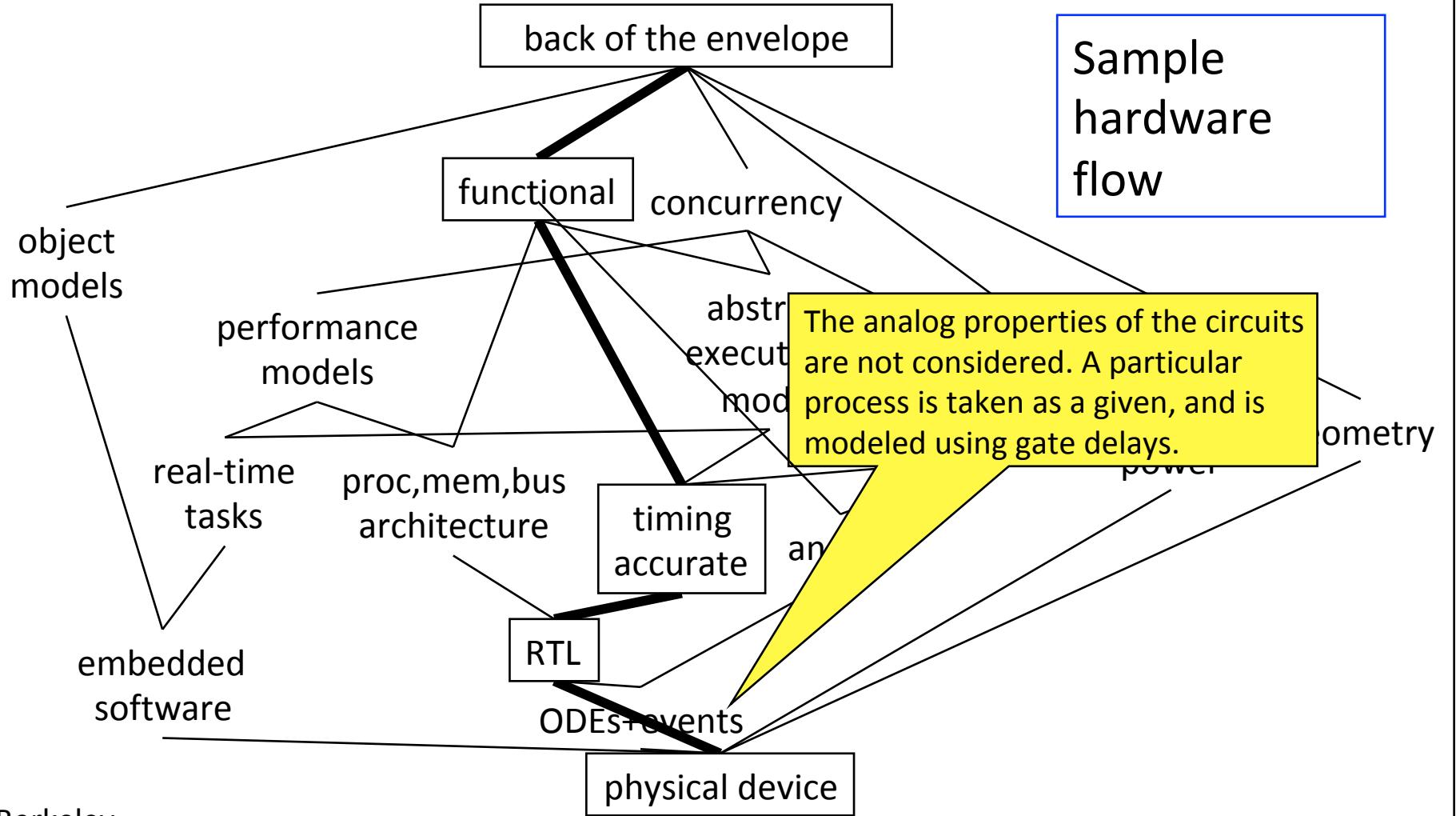


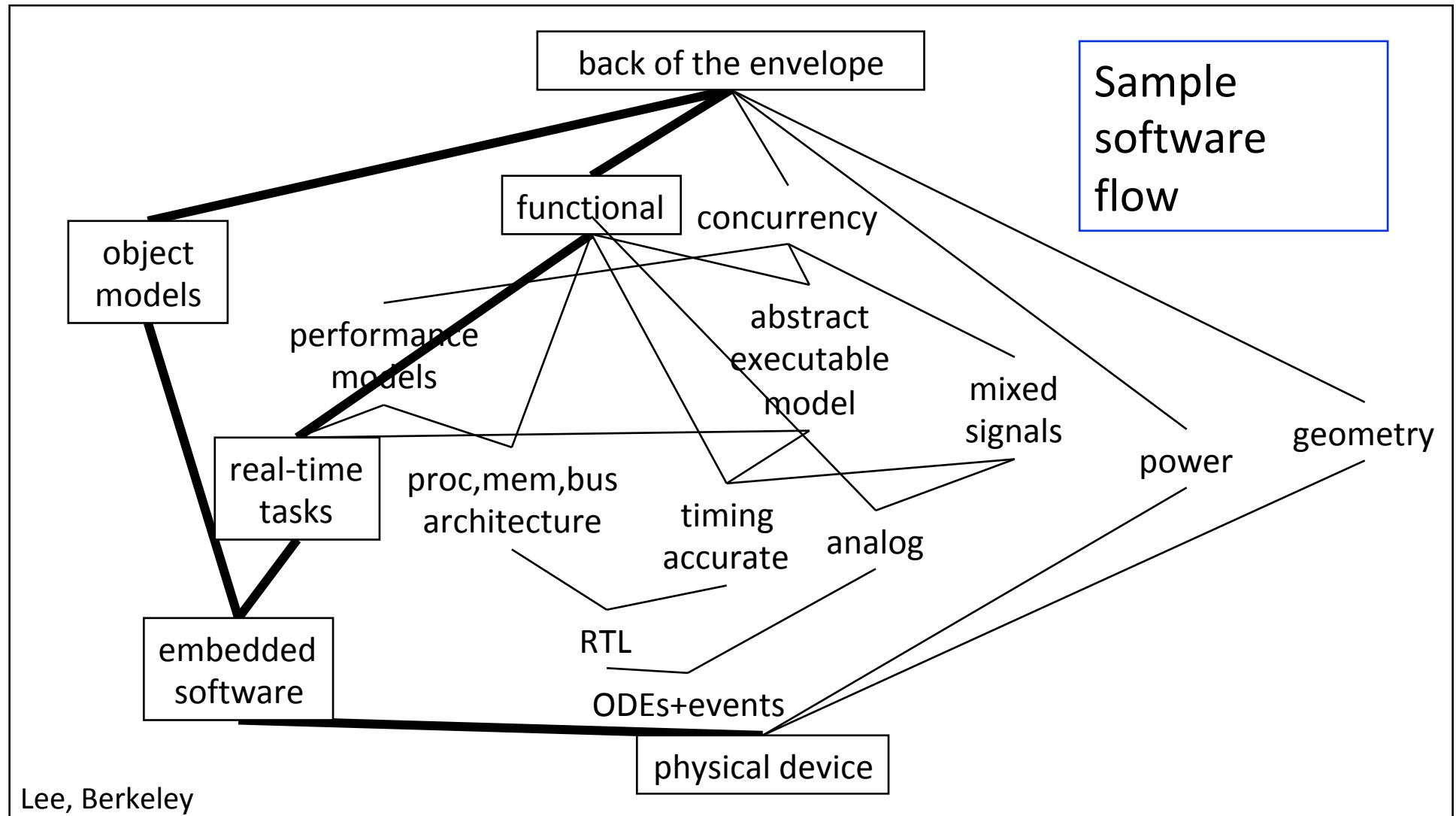


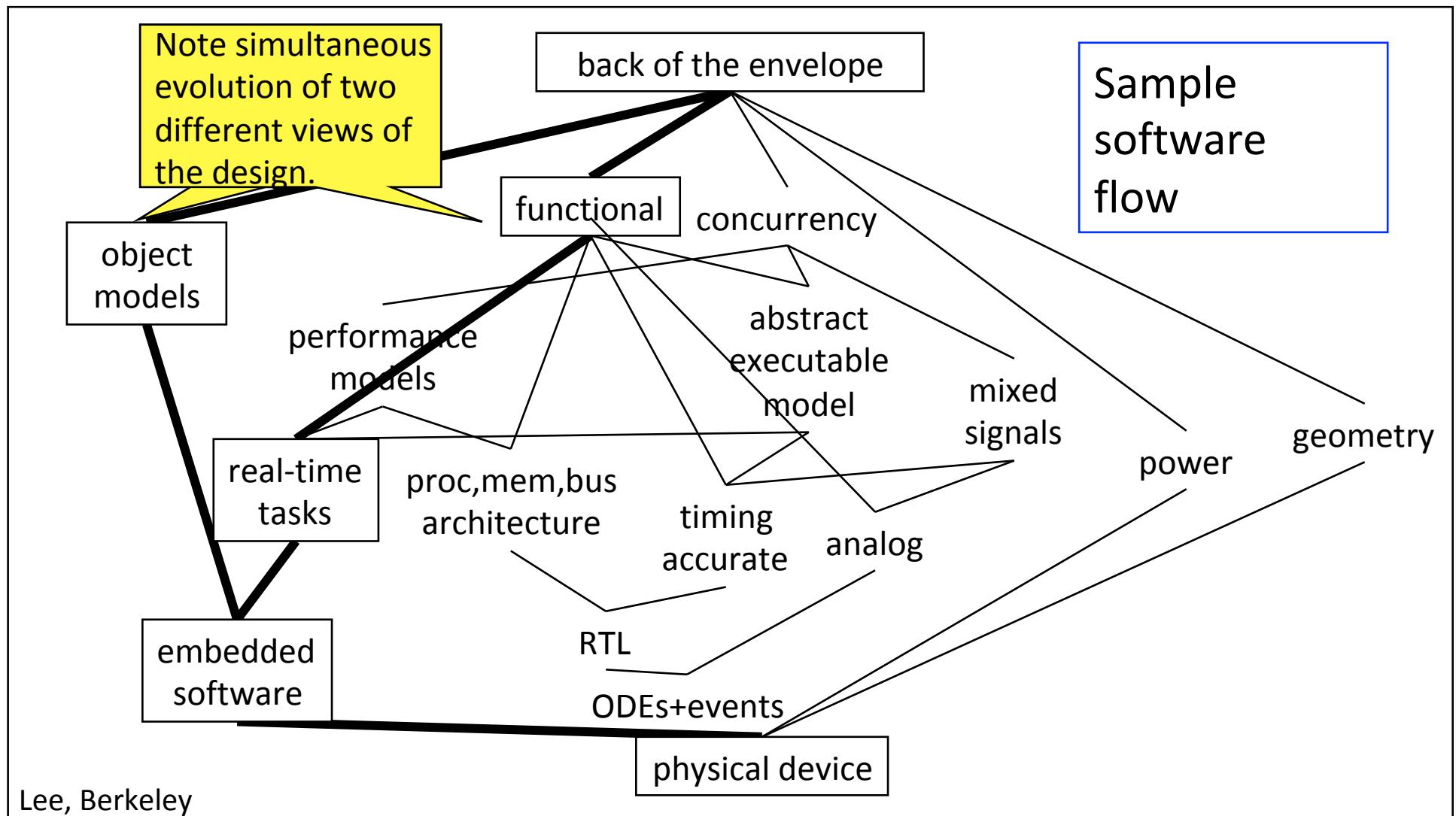








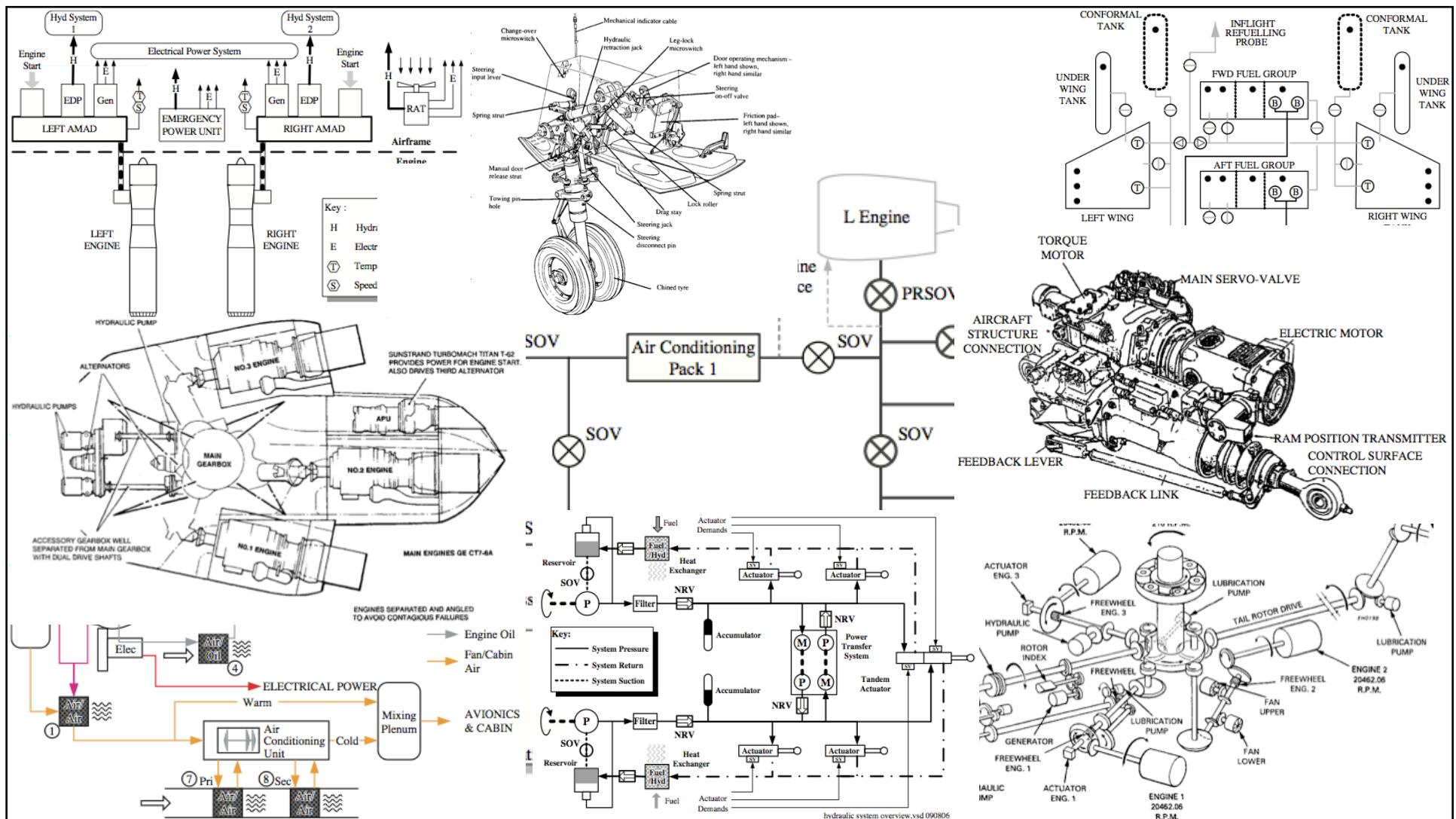




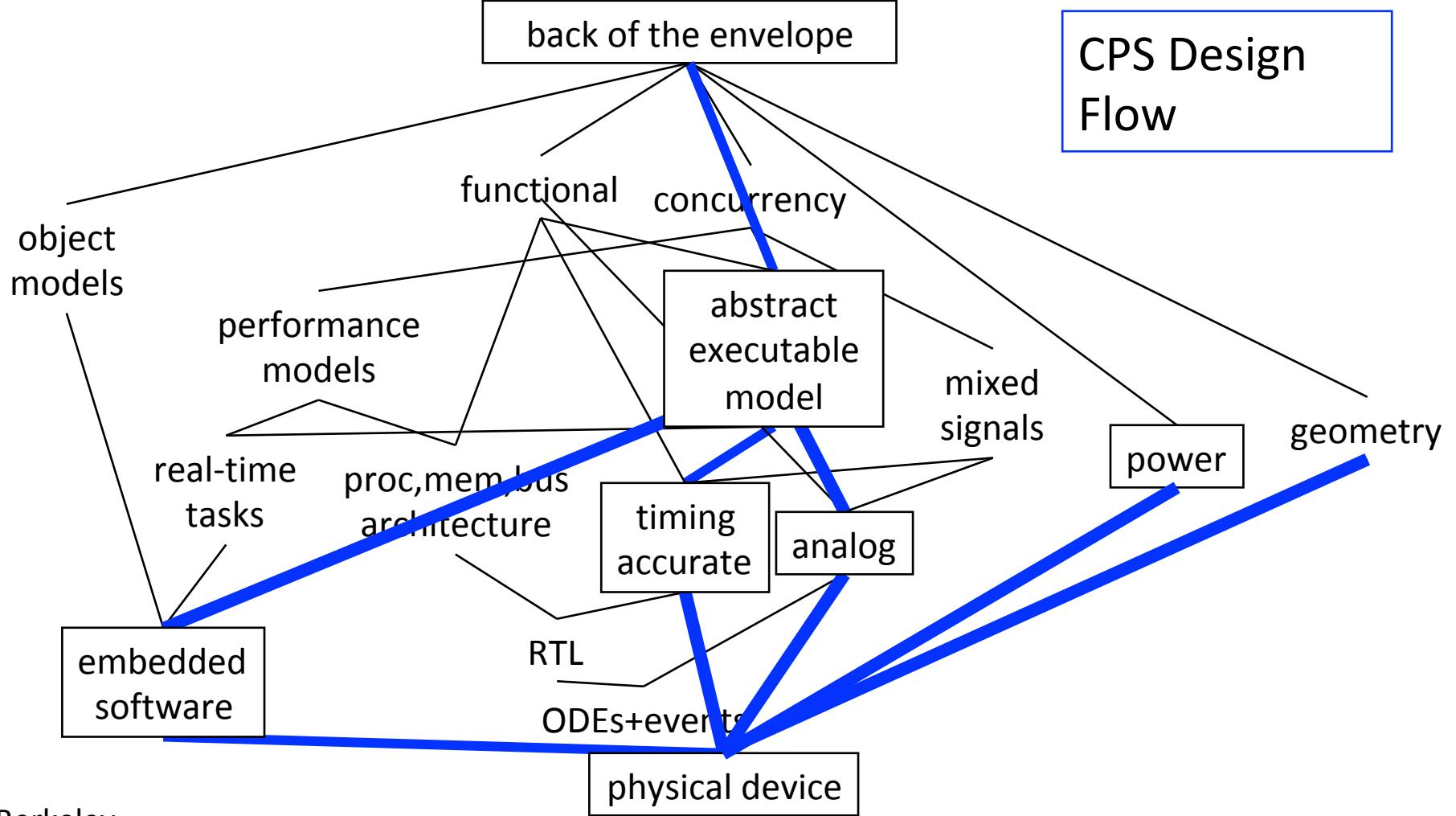


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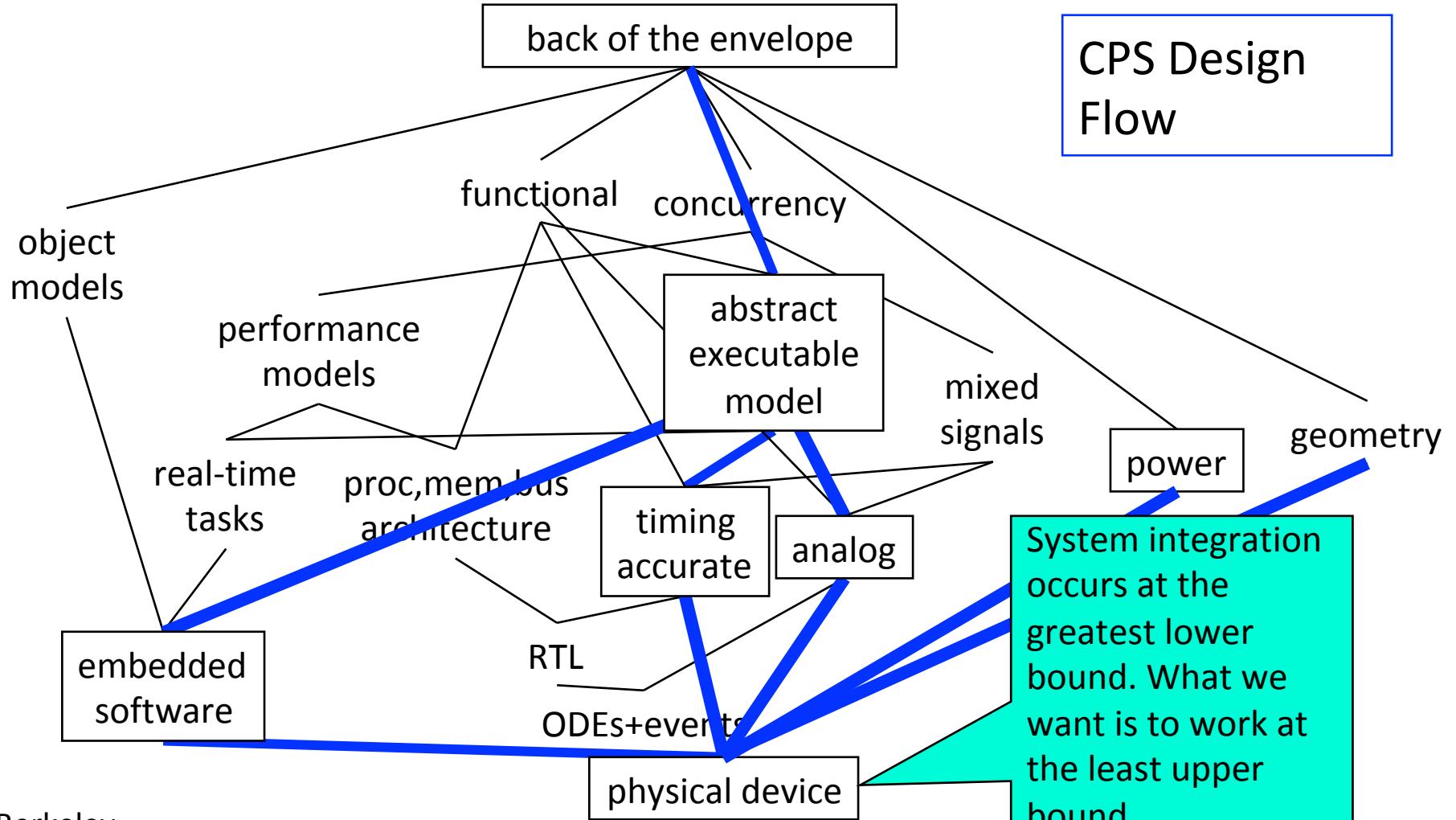


## CPS Design Flow



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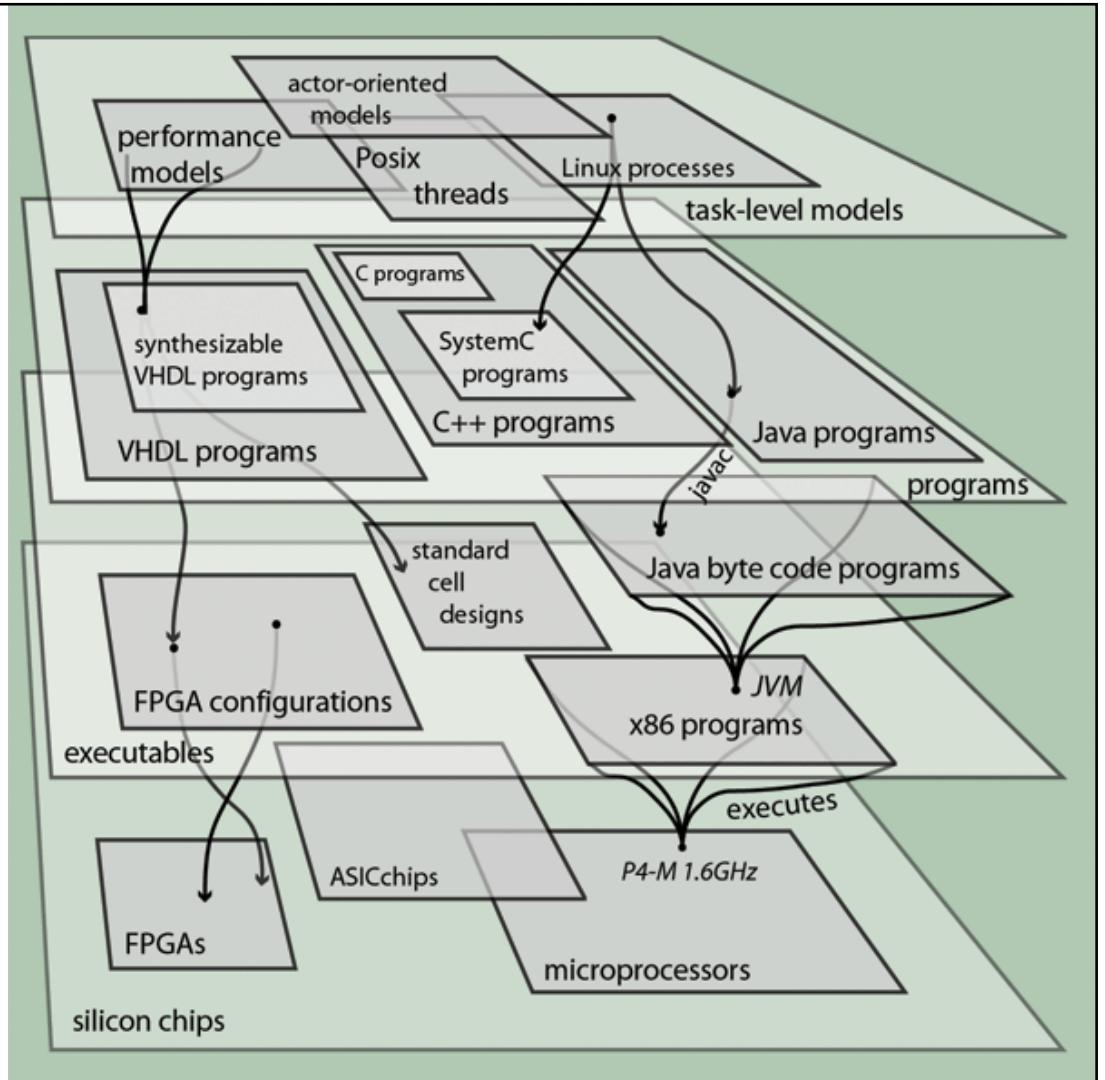
## CPS Design Flow



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# Platforms

The purpose for an abstraction is to hide details of the implementation below and provide a platform for design from above.





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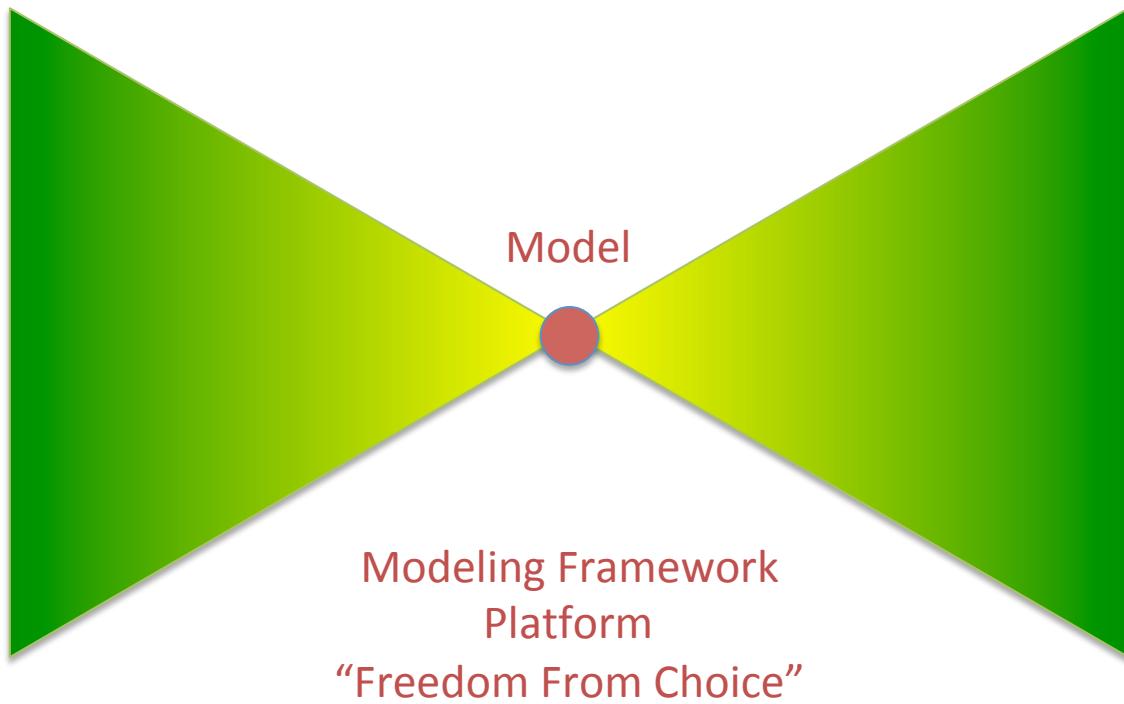
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# Life Without Platforms

Every abstraction layer has failed in the fly-by-wire scenario.

The design *is* the implementation.

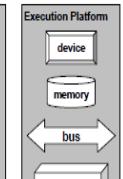




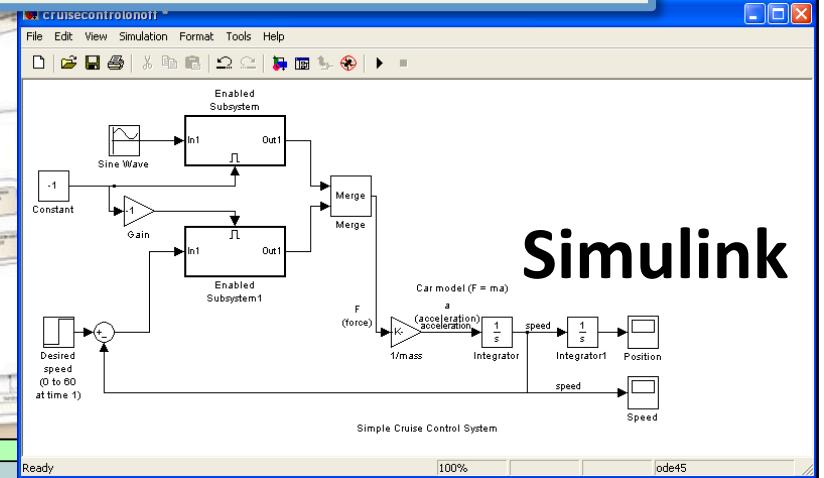
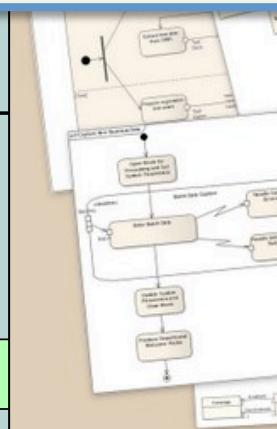
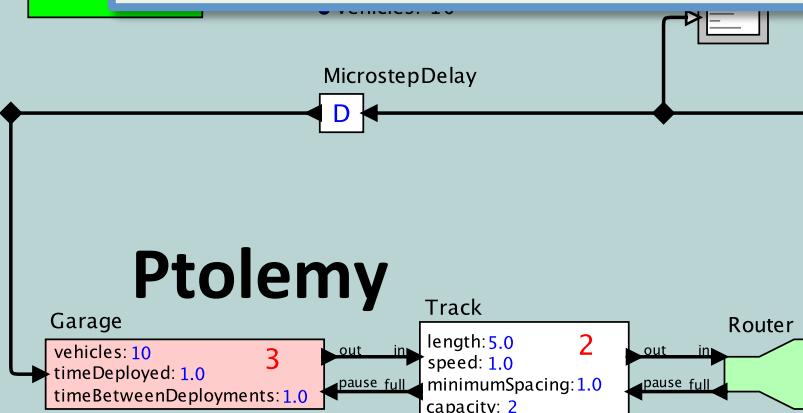
# What is a Model?



AADL



A model is any description of a system that is  
not the thing-in-itself.  
*(das Ding an sich in Kantian philosophy).*



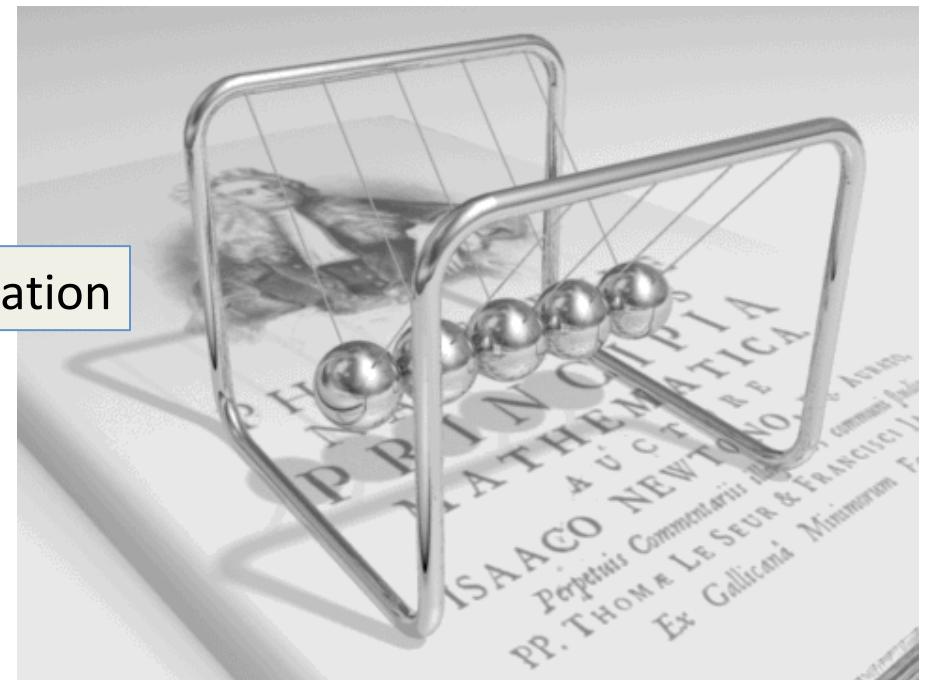
# A Modeling Framework

$$x(t) = x(0) + \int_0^t v(\tau) d\tau$$

The model

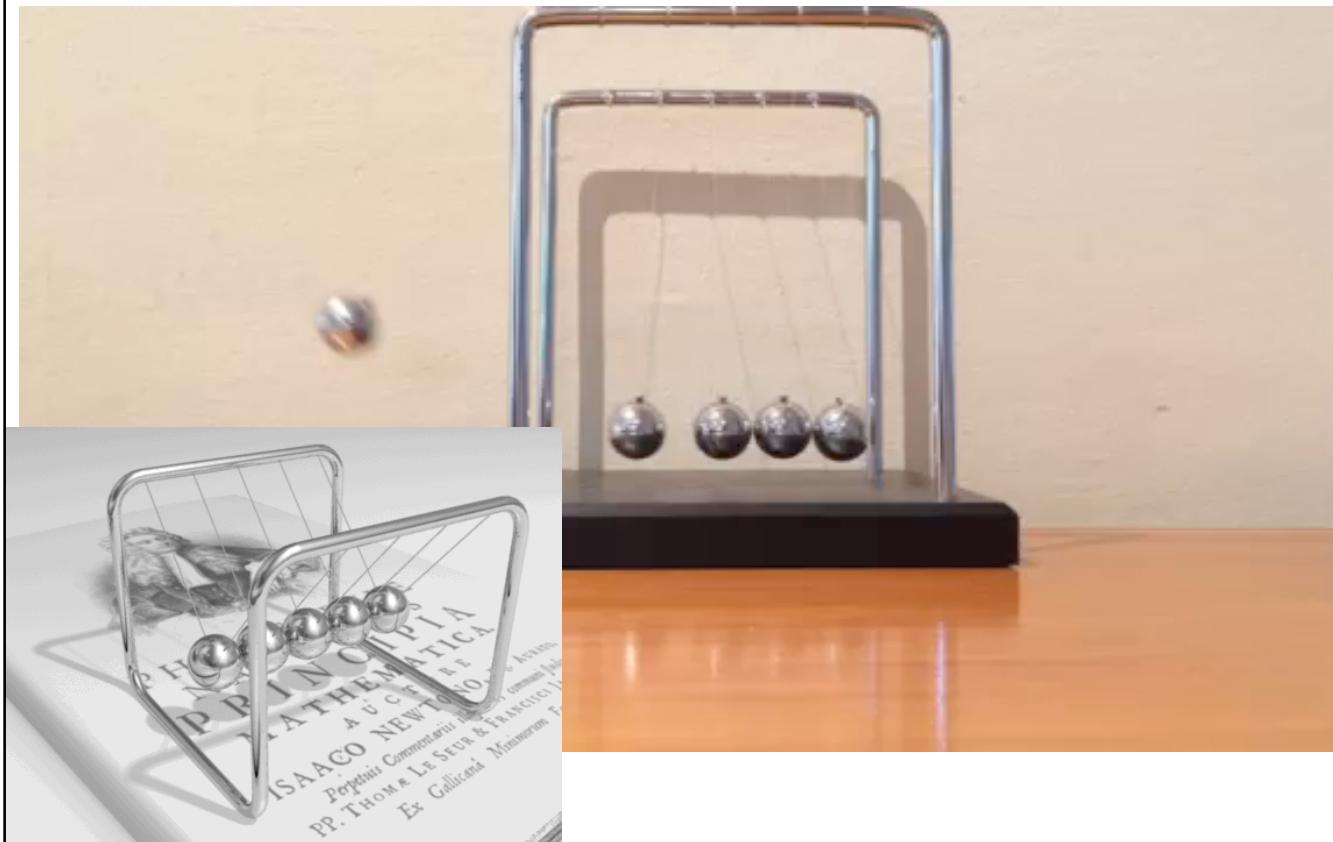
$$v(t) = v(0) + \frac{1}{m} \int_0^t F(\tau) d\tau.$$

Simulation



In this example, the *modeling framework* or *platform* is calculus and Newton's laws in a time and space continuum.

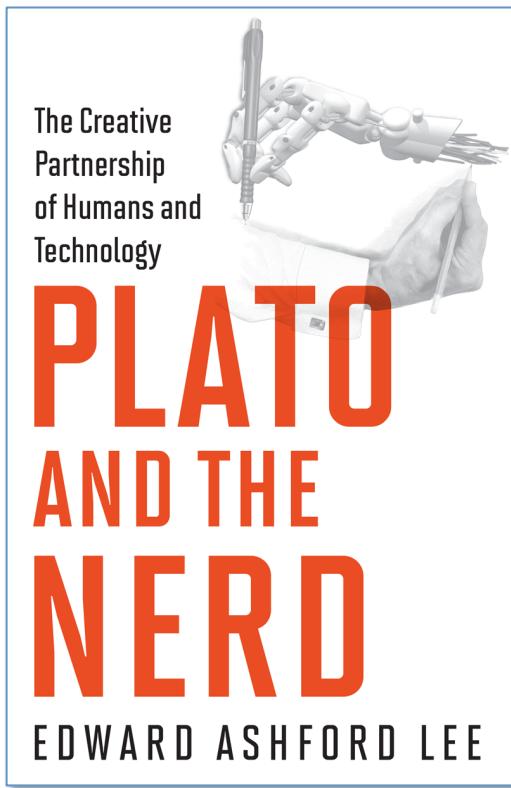
# The Map and the Territory



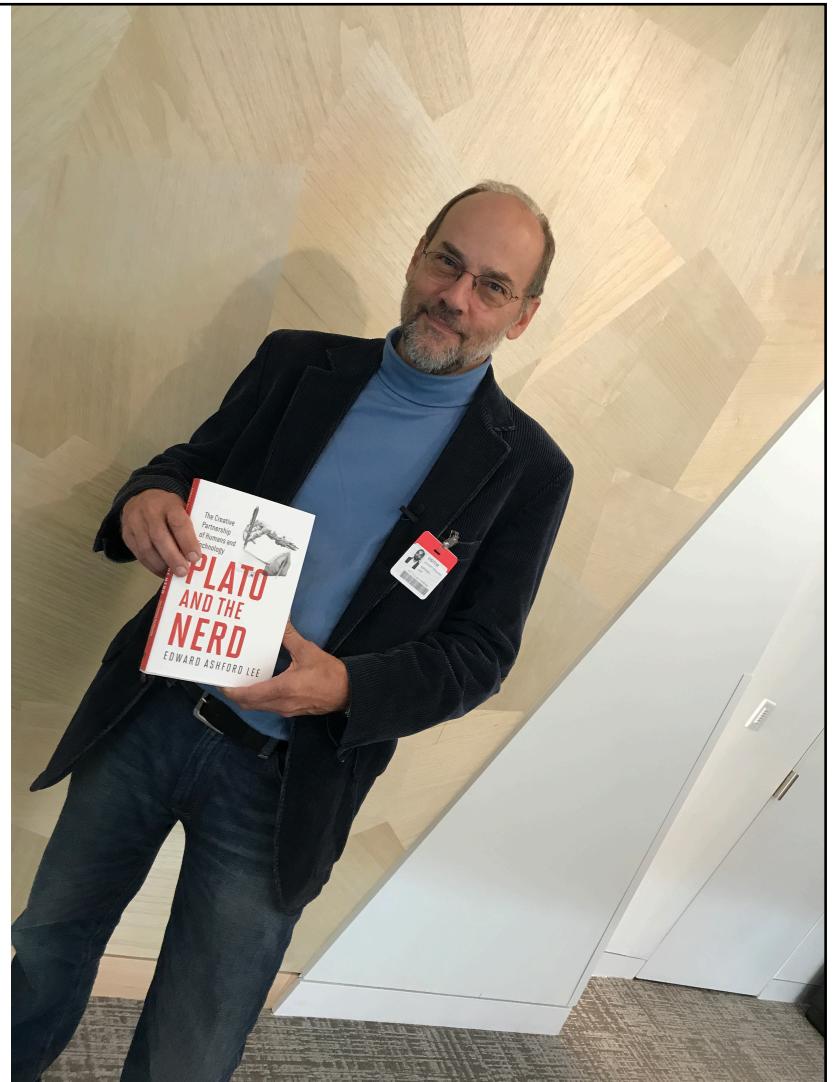
A few things we need to model to explain this behavior:

- Plastic deformation
- Acoustic propagation
- Stretching of strings
- ...

# An Epiphany



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## The Value of Models

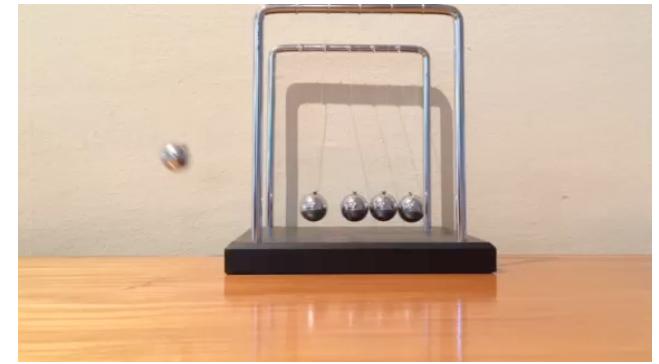
- In *science*, the value of a *model* lies in how well its behavior matches that of the physical system.
- In *engineering*, the value of the *physical system* lies in how well its behavior matches that of the model.

A scientist asks, “Can I make a model for this thing?”

An engineer asks, “Can I make a thing for this model?”

## Model Fidelity

- To a *scientist*, the model is flawed.
- To an *engineer*, the realization is flawed.



I'm an engineer...

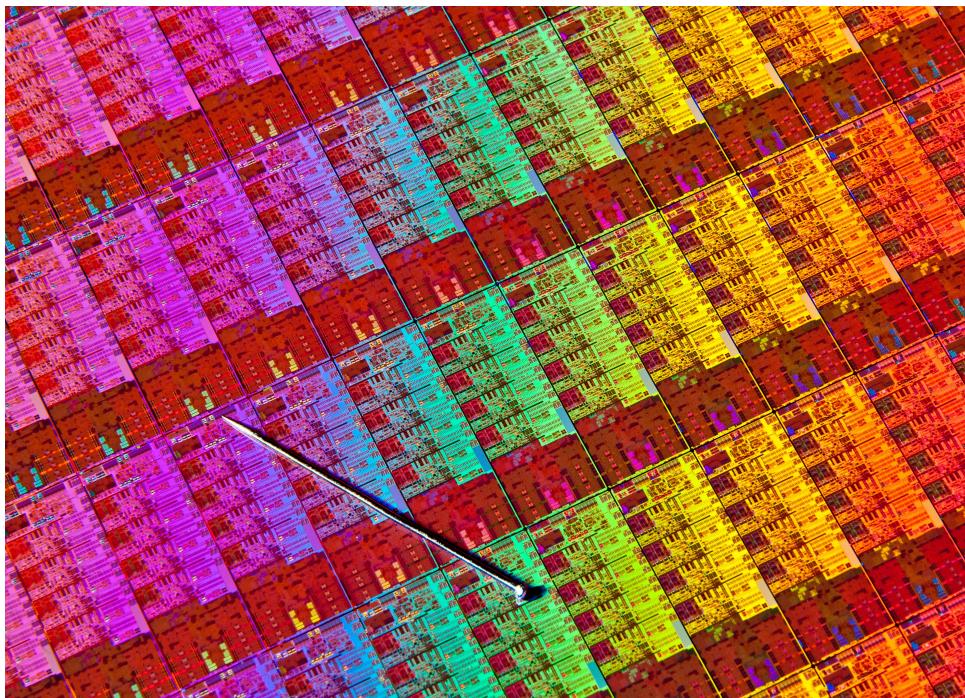
## Changing the Question

Is the question whether we can build models describing the behavior of our systems?

Or

Is the question whether we can build systems whose behavior matches that of our models?

## Consider Chip Design



A piece of silicon that  
doesn't behave like the  
model is just beach sand.

Intel Haswell, each with 1.4 billion transistors

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# Useful Models and Useful Things

“Essentially, all models are wrong,  
but some are useful.”

Box, G. E. P. and N. R. Draper, 1987: *Empirical Model-Building and Response Surfaces*. Wiley Series in Probability and Statistics, Wiley.

“Essentially, all system implementations  
are wrong, but some are useful.”

Lee and Sirjani, “What good are models,” FACS 2018.

# The Value of Simulation

“Simulation is doomed to succeed.”

Could this statement be confusing engineering and scientific models?



**Figure 1: Three scenes generated from a single ~20-line SCENIC scenario representing bumper-to-bumper traffic.**

[Fremont, et al., Scenic: Language-Based Scene Generation, Arxiv.org, Sept. 2018]

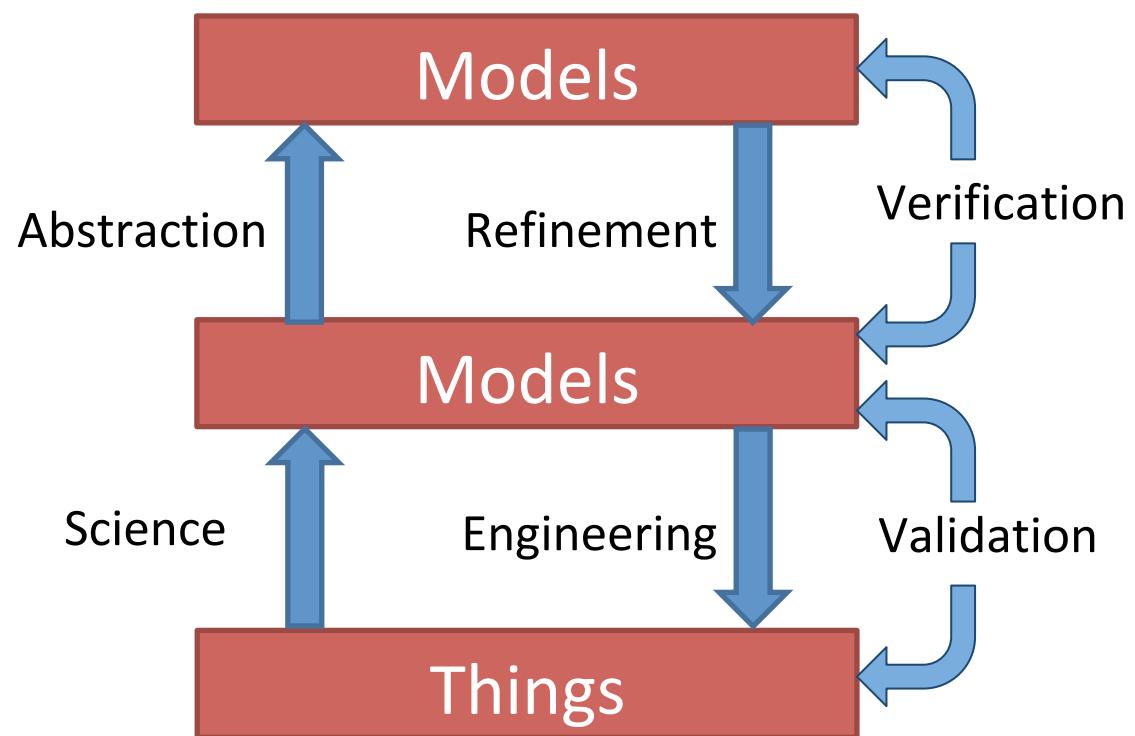
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# Towards *Engineering*-Model-Based Design

Per Barry Boehm:

- Am I building the right product? (validation)
- Am I building the product right? (verification)



# Raphael: The School of Athens

