



iCyPhy



# Freedom from Choice and the Power of Models

*In Honor of Alberto Sangiovanni-Vincentelli*

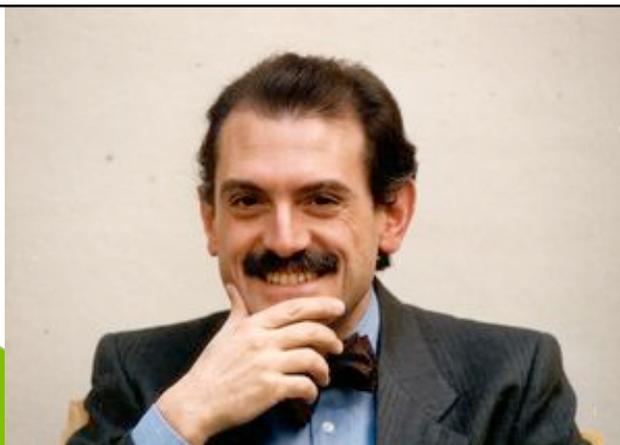
*Edward A. Lee*

**UC Berkeley**

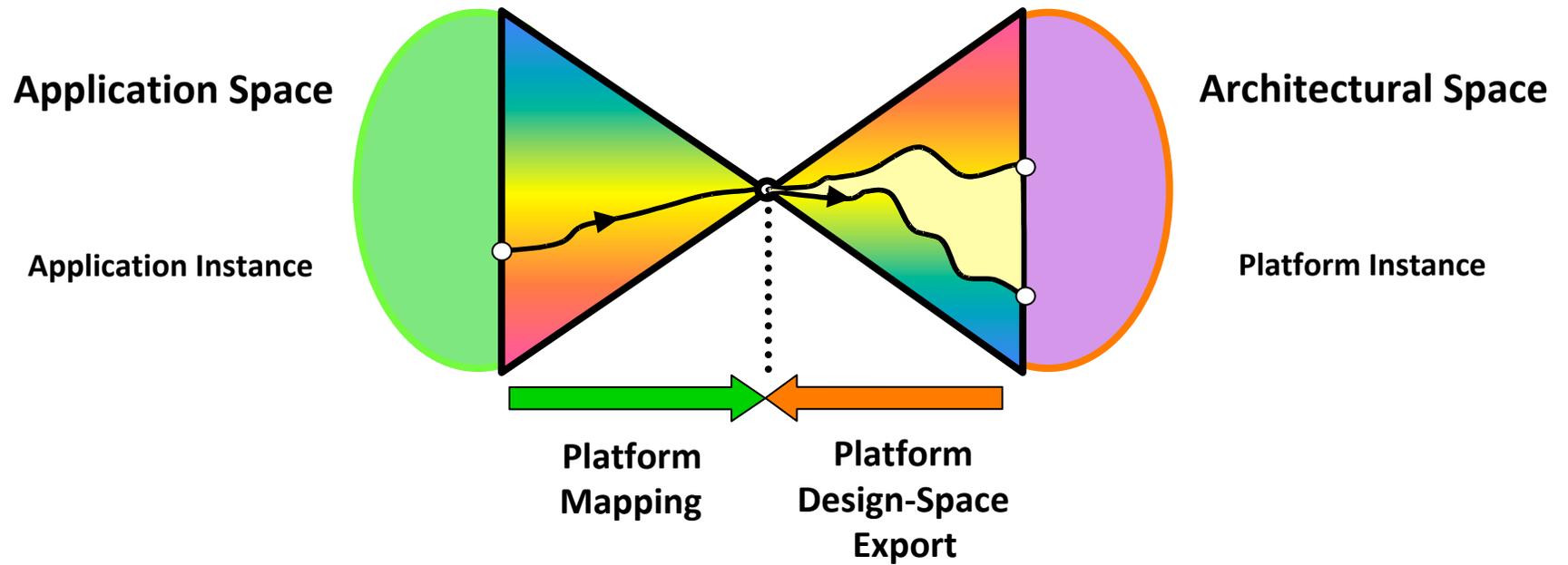
*Keynote, International Symposium on Physical Design (IPSN)  
San Francisco, CA, April 16, 2019*

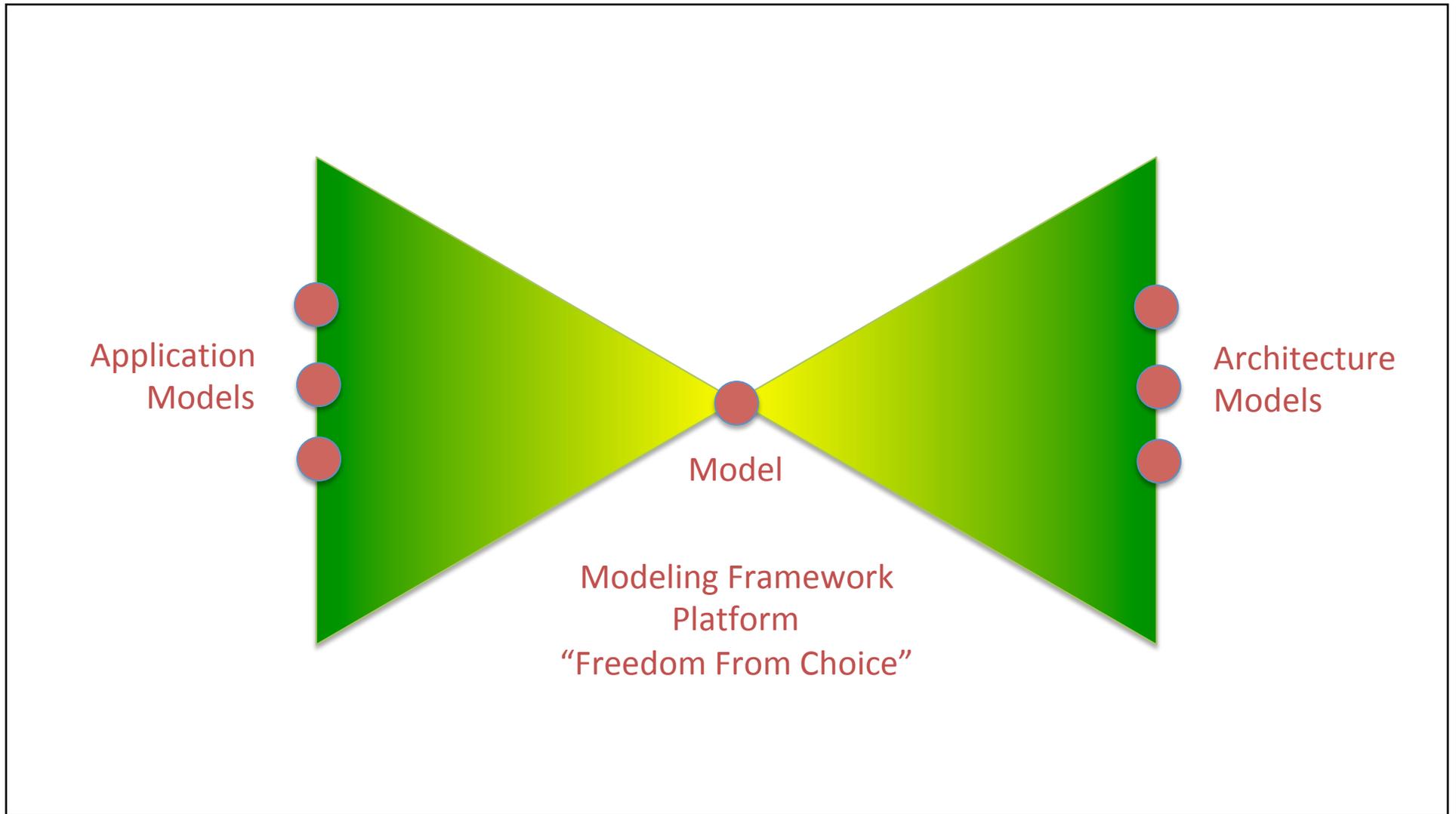


**University of California at Berkeley**



# Platform-Based Design





Application  
Models

Architecture  
Models

Model

Modeling Framework  
Platform  
"Freedom From Choice"

If this is not clear to you...

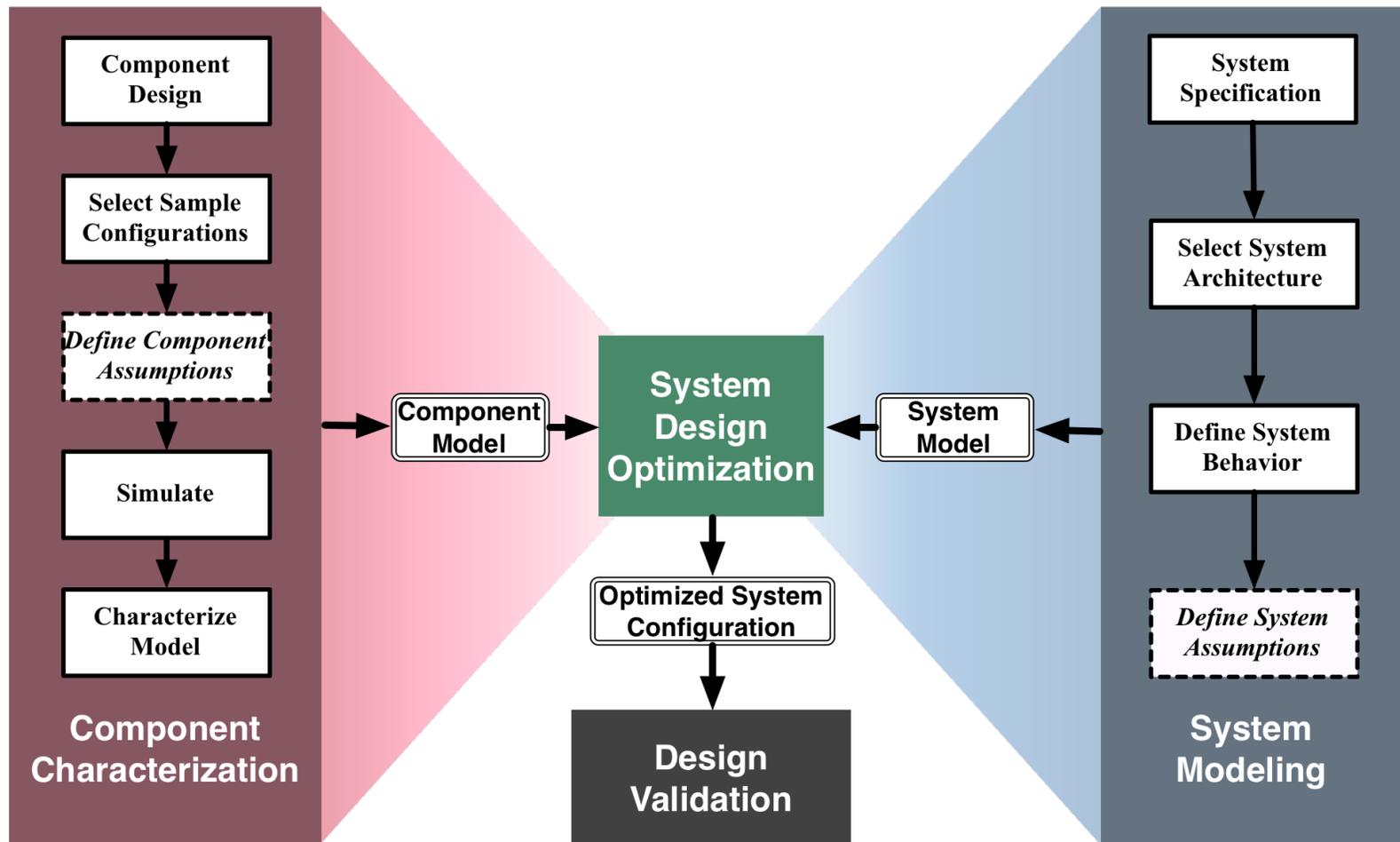
O ye possessed of sturdy intellects,  
observe the teaching that is hidden here  
beneath the veil of verses so obscure.

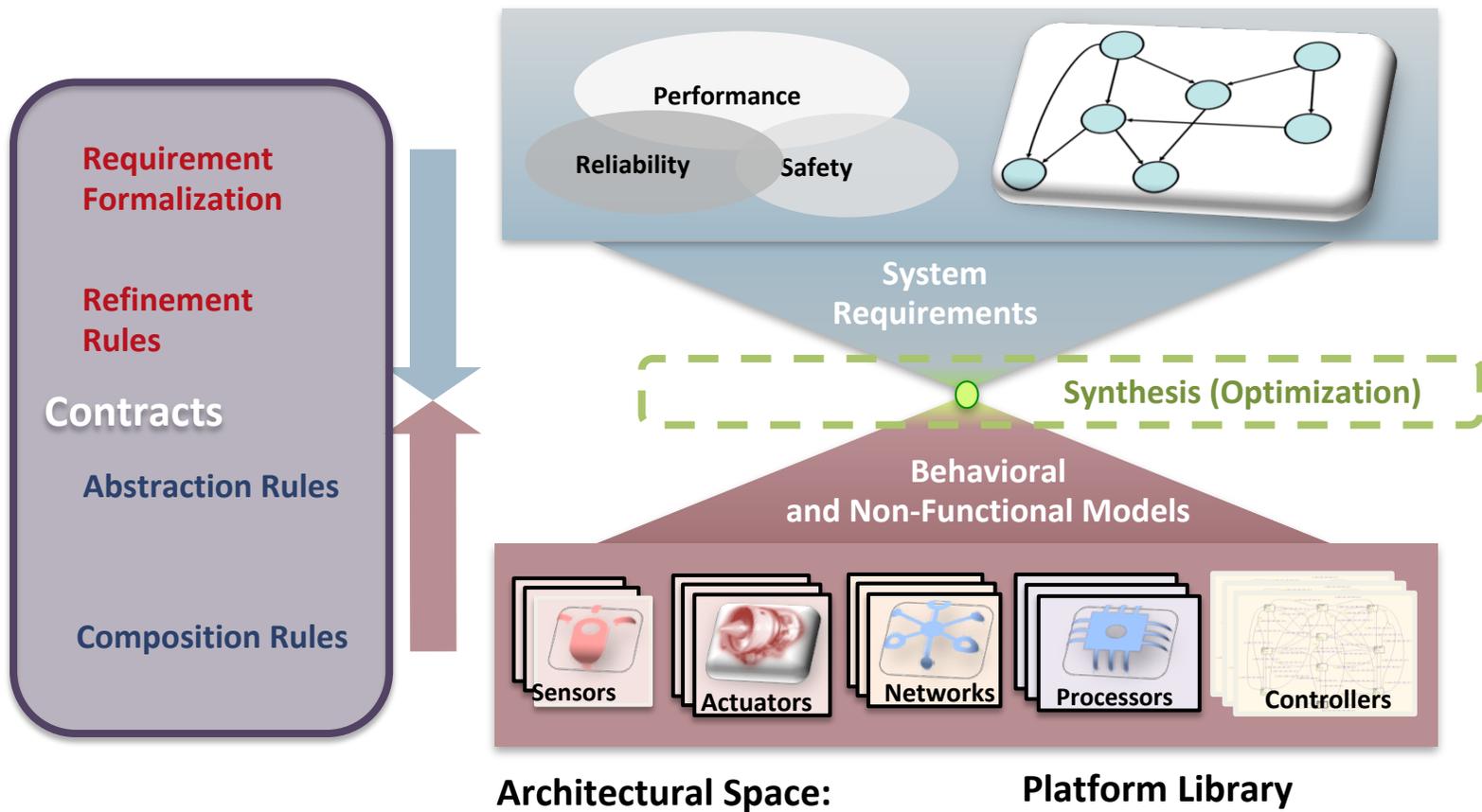
*Dante*

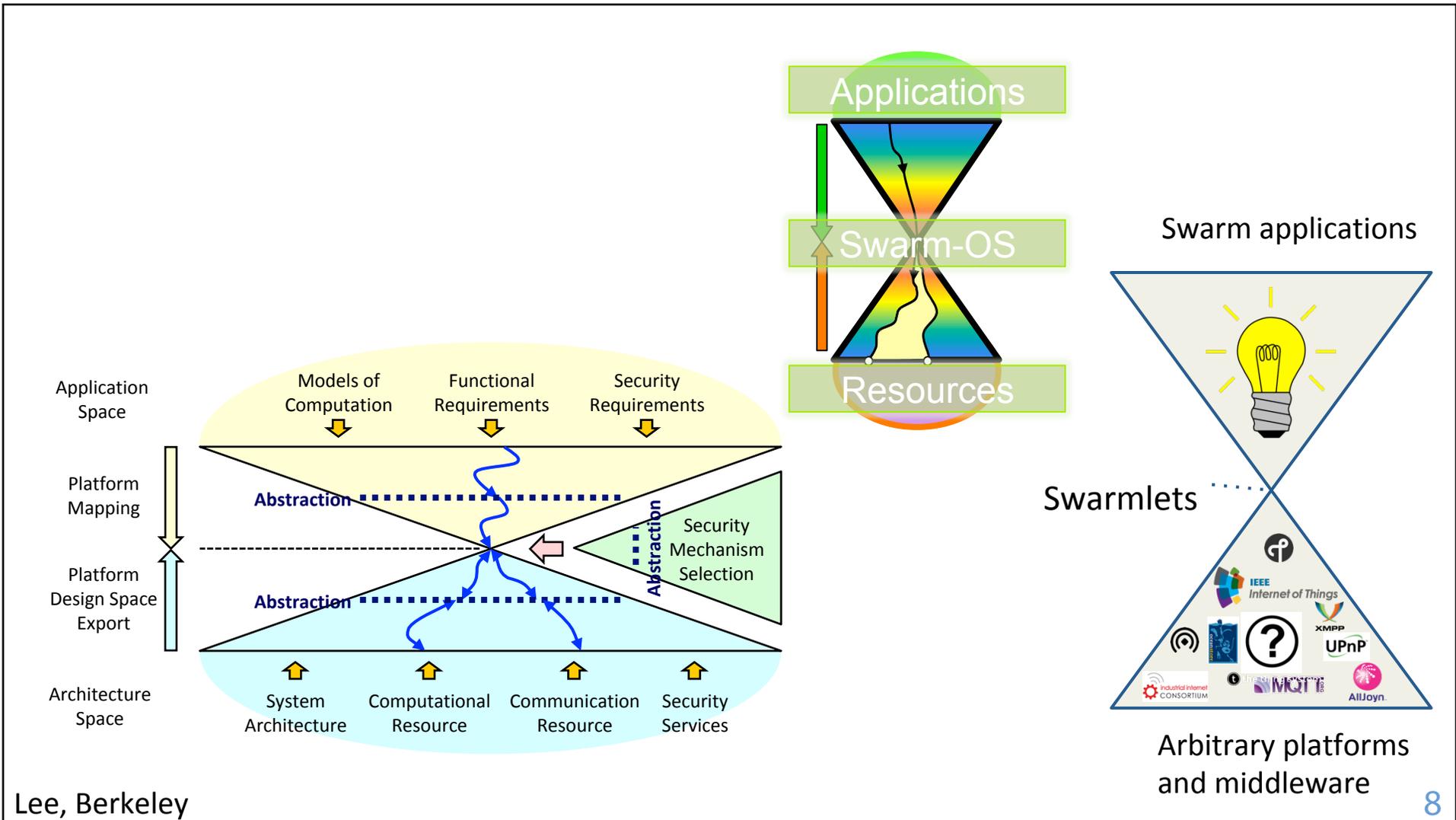
*Divine Comedy, Inferno, Canto 9*

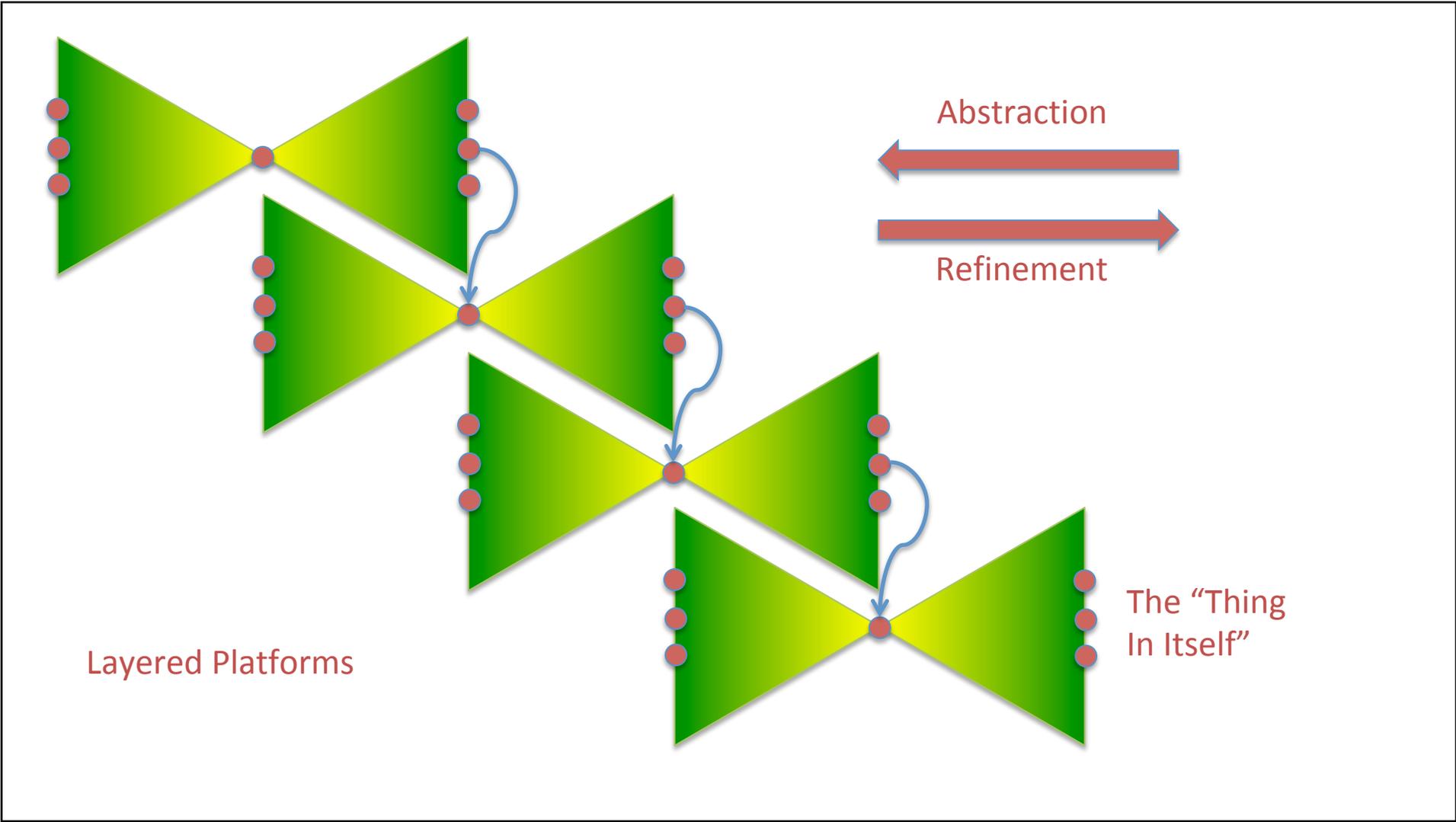
Lee, Berkeley

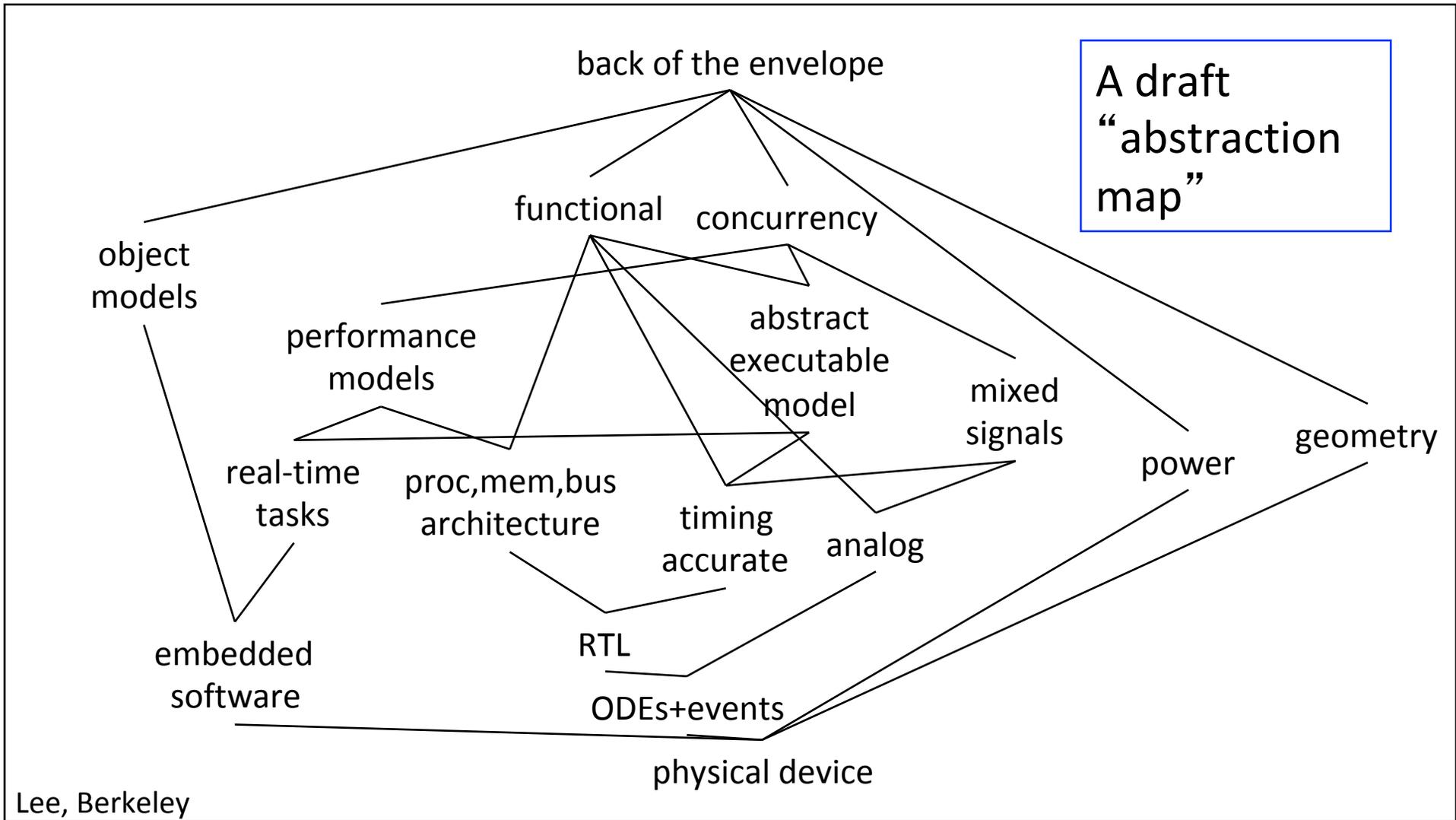


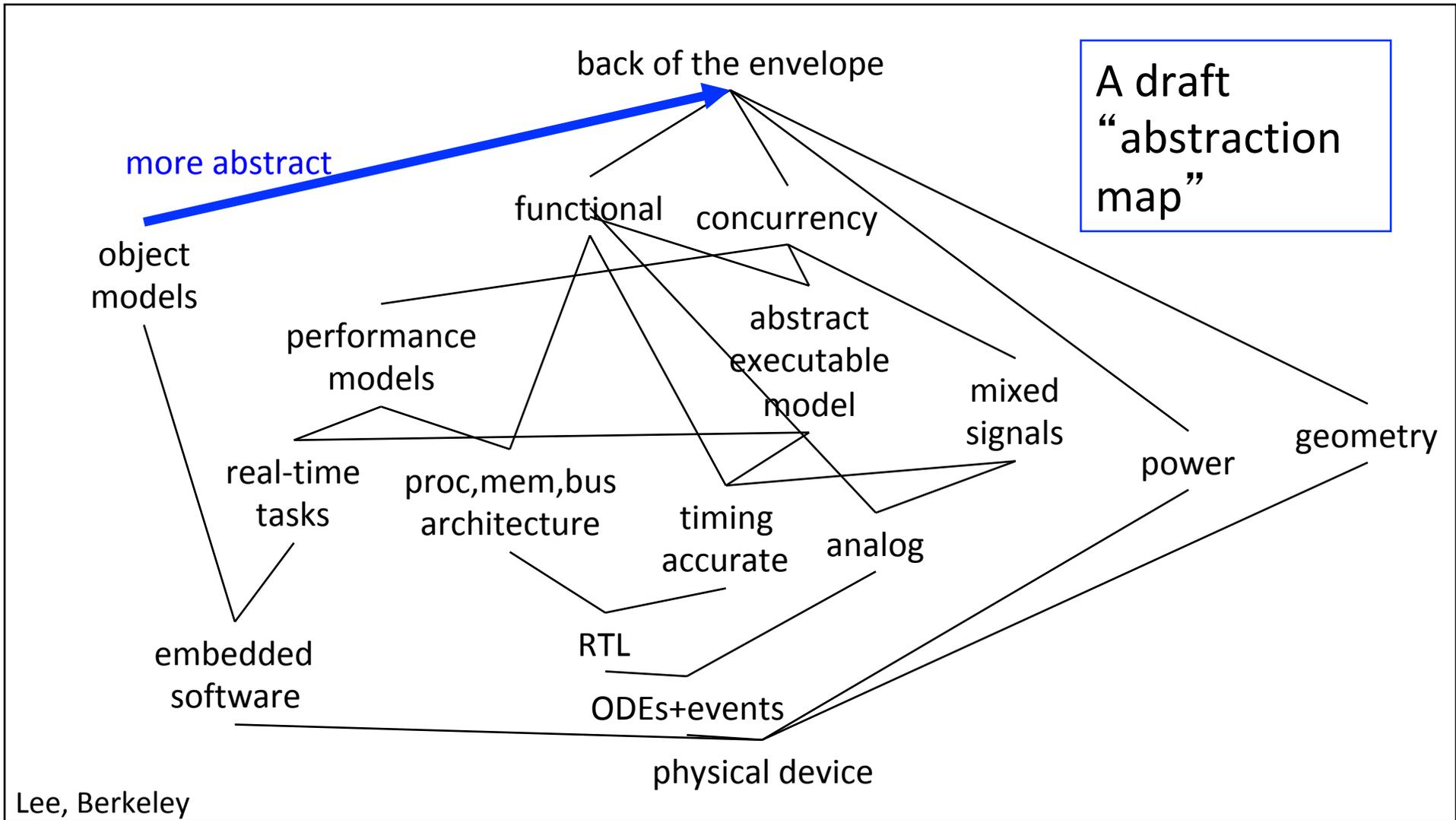


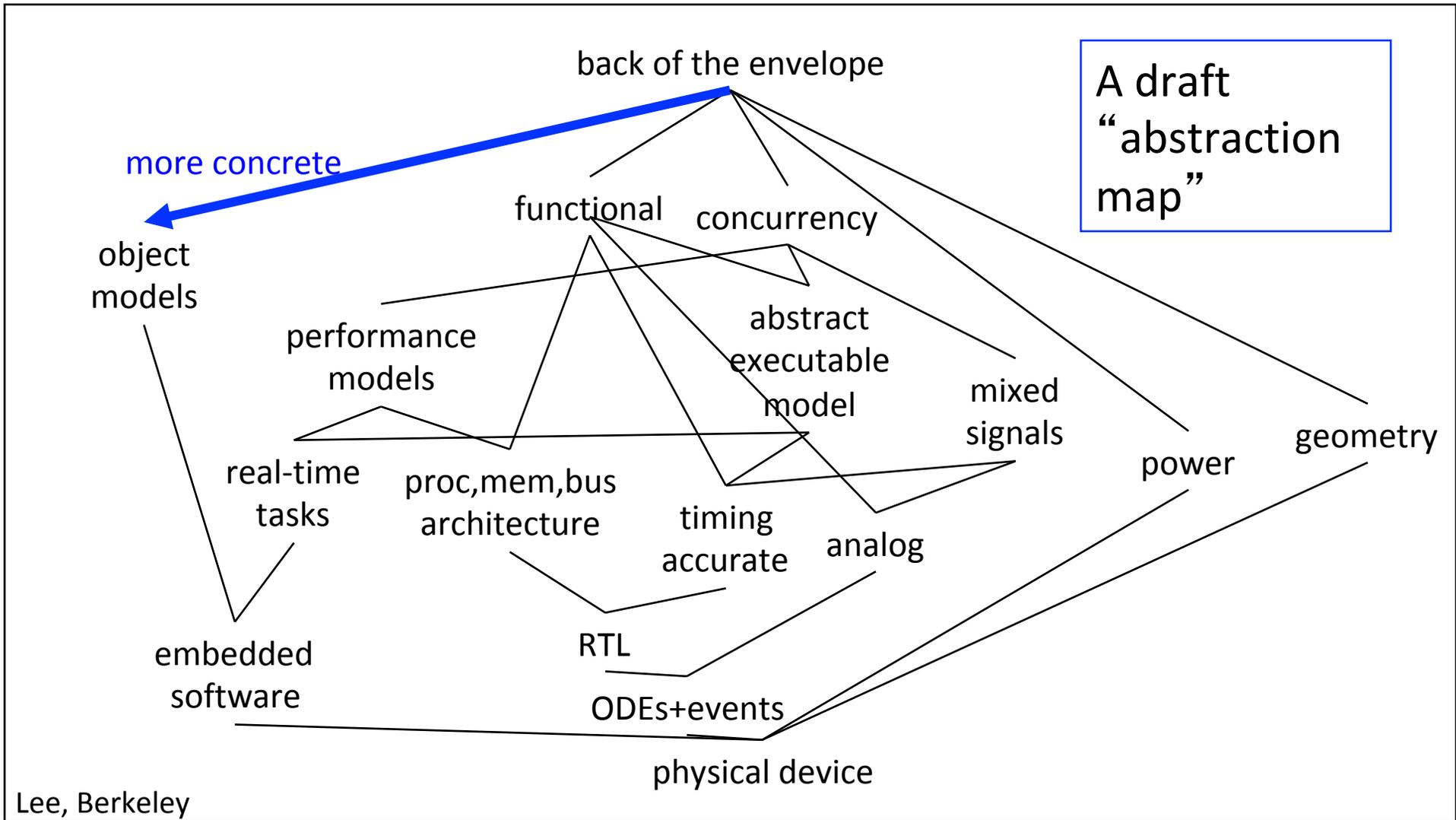


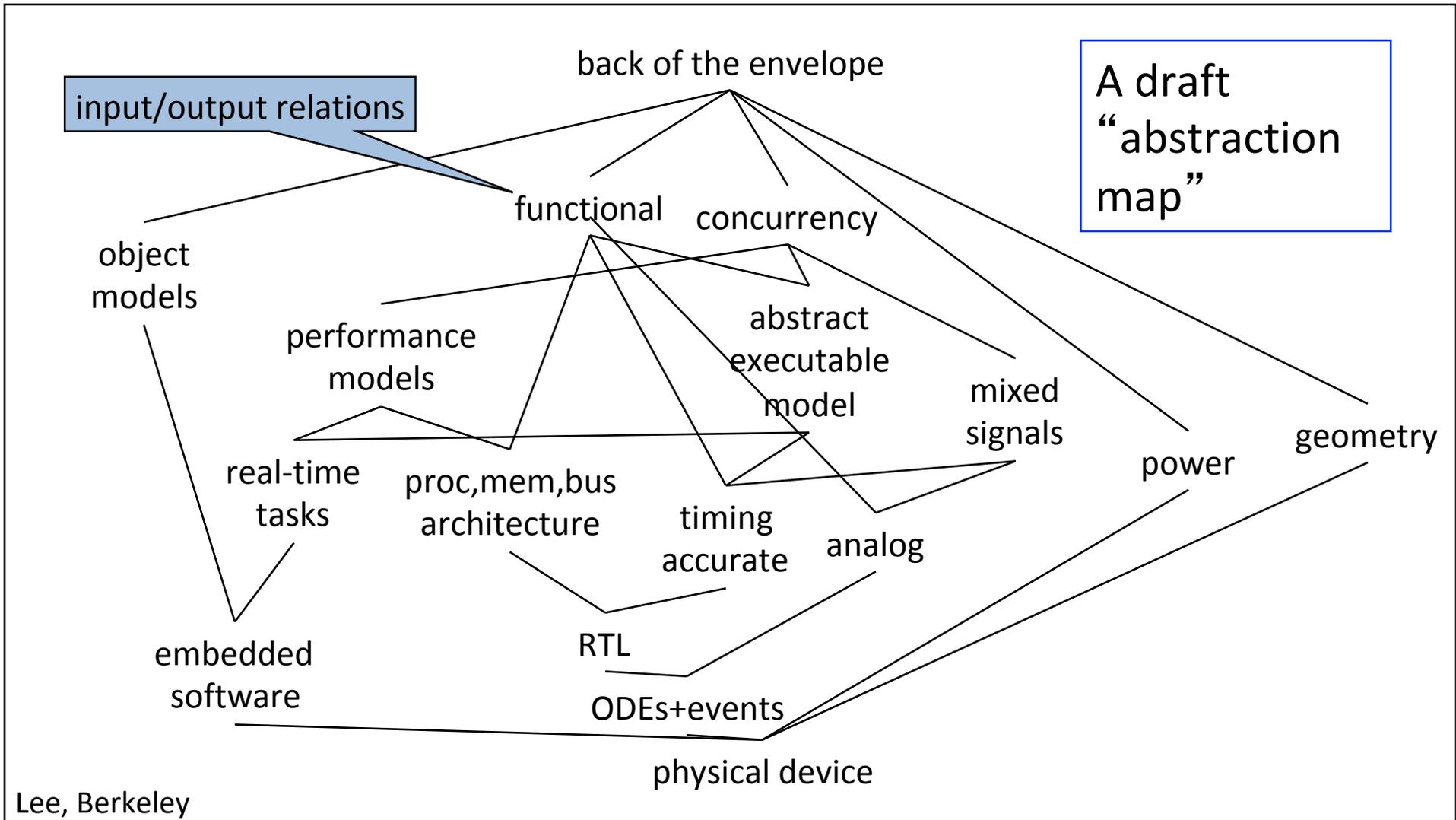












input/output relations

A draft  
"abstraction  
map"

back of the envelope

functional

concurrency

object  
models

performance  
models

abstract  
executable  
model

mixed  
signals

real-time  
tasks

proc,mem,bus  
architecture

timing  
accurate

analog

power

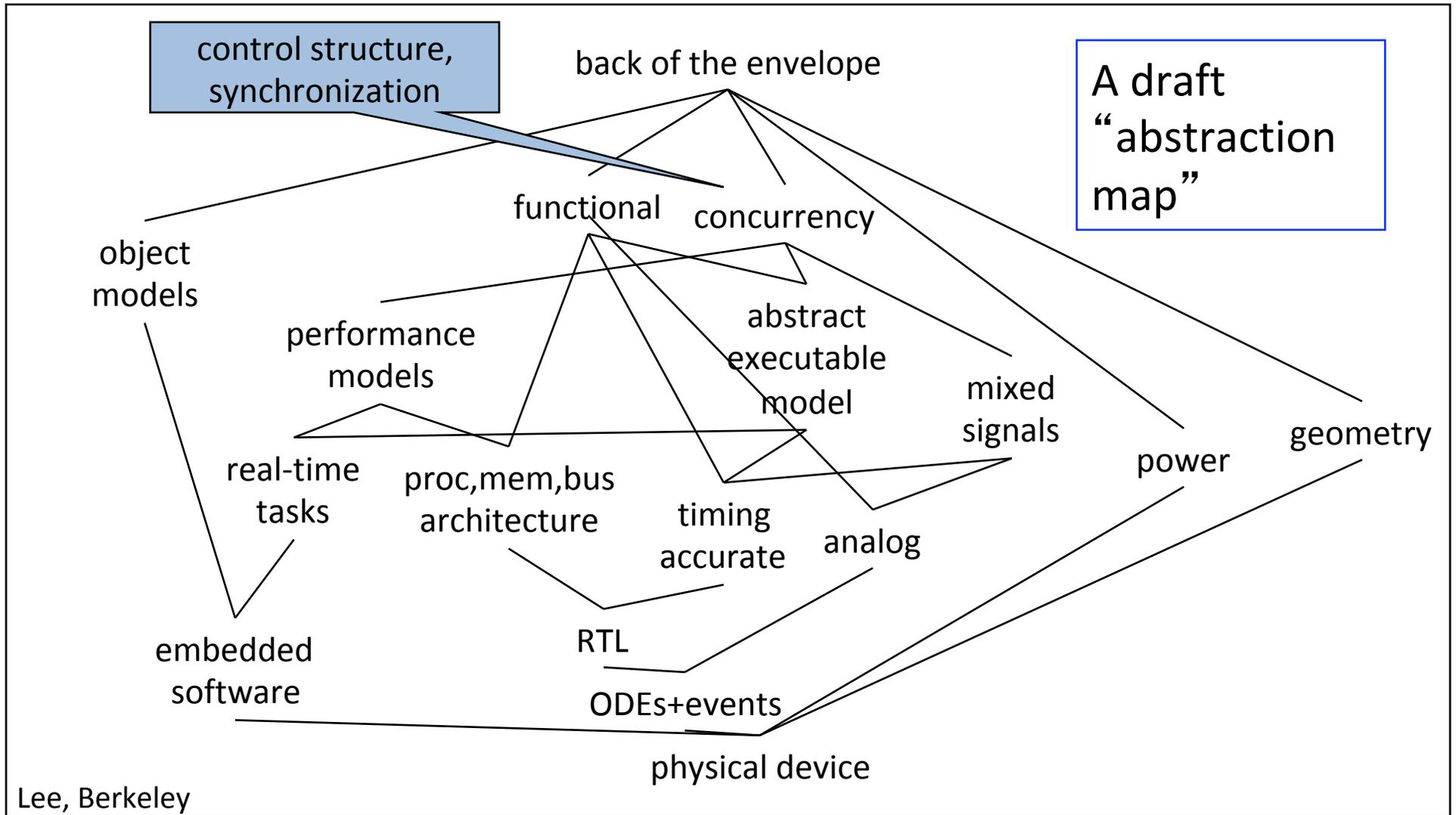
geometry

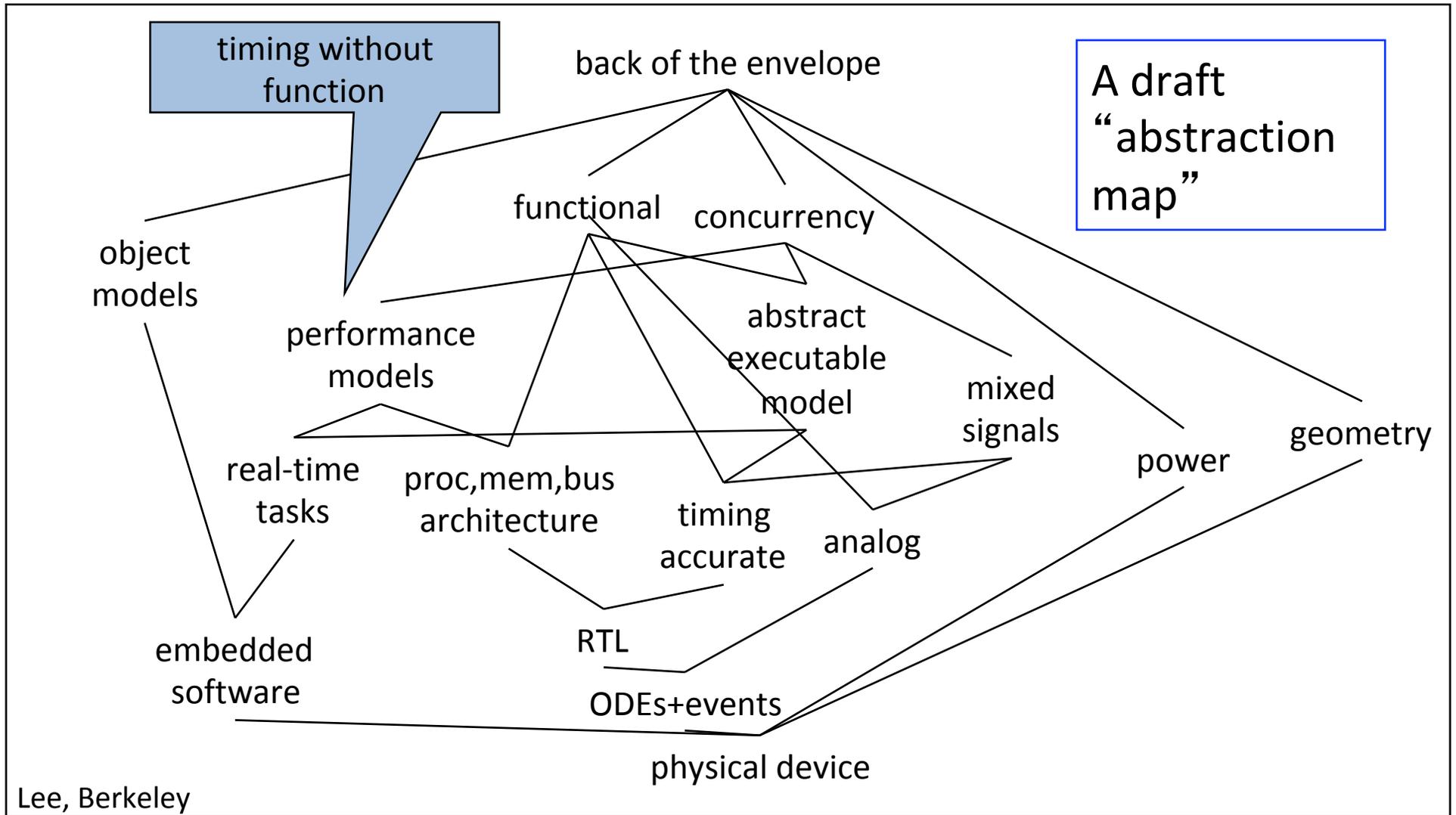
embedded  
software

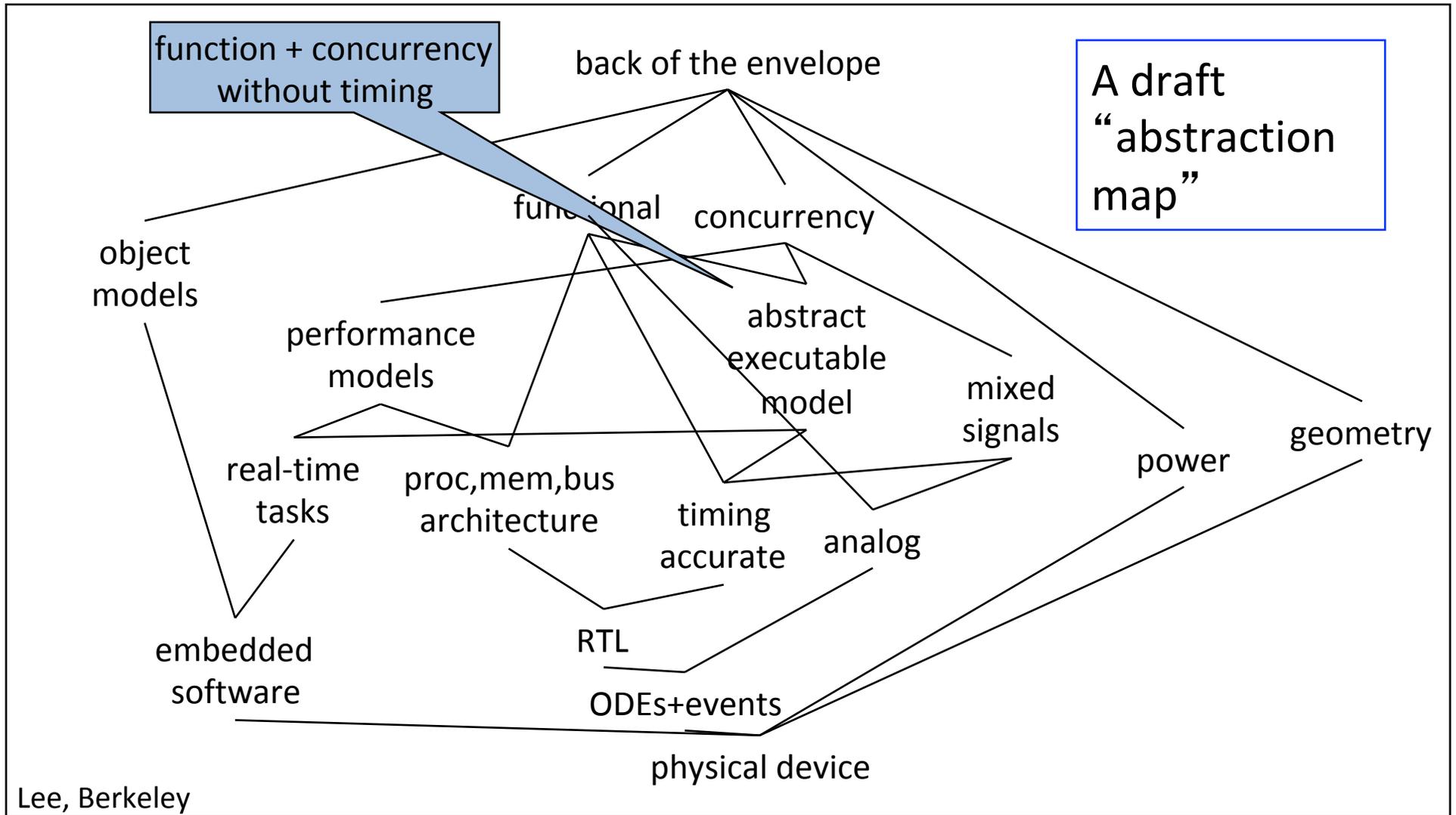
RTL

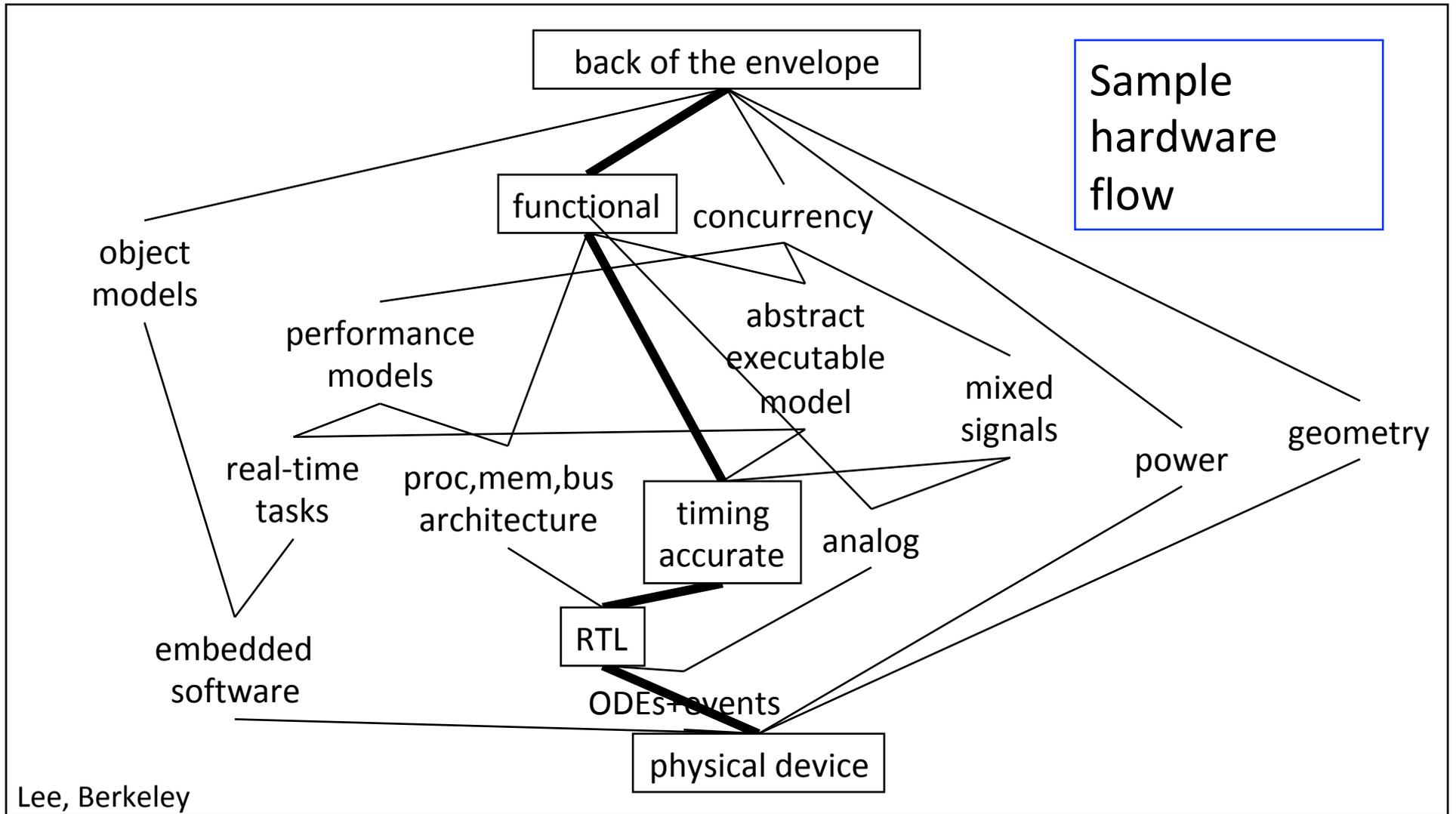
ODEs+events

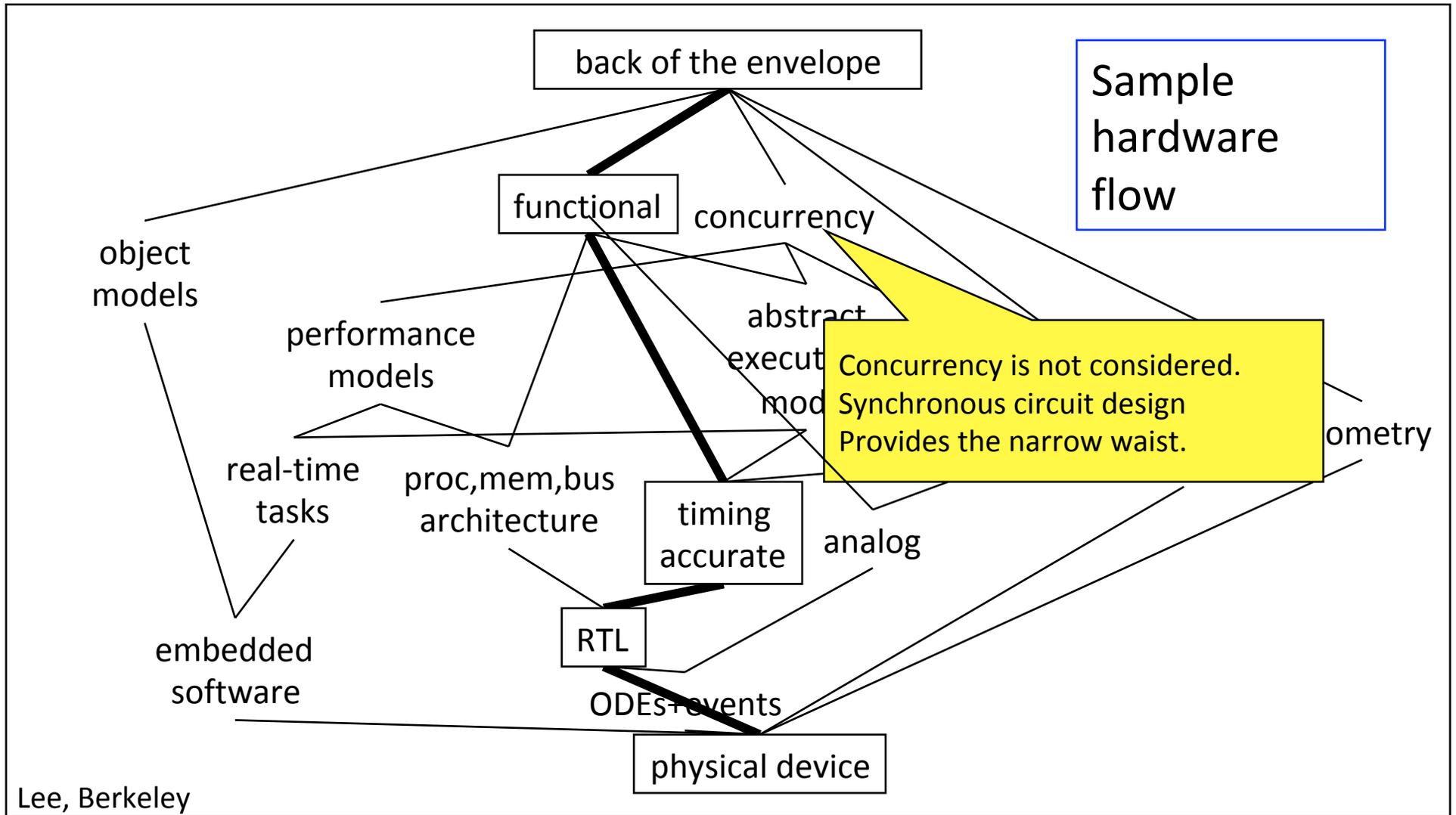
physical device

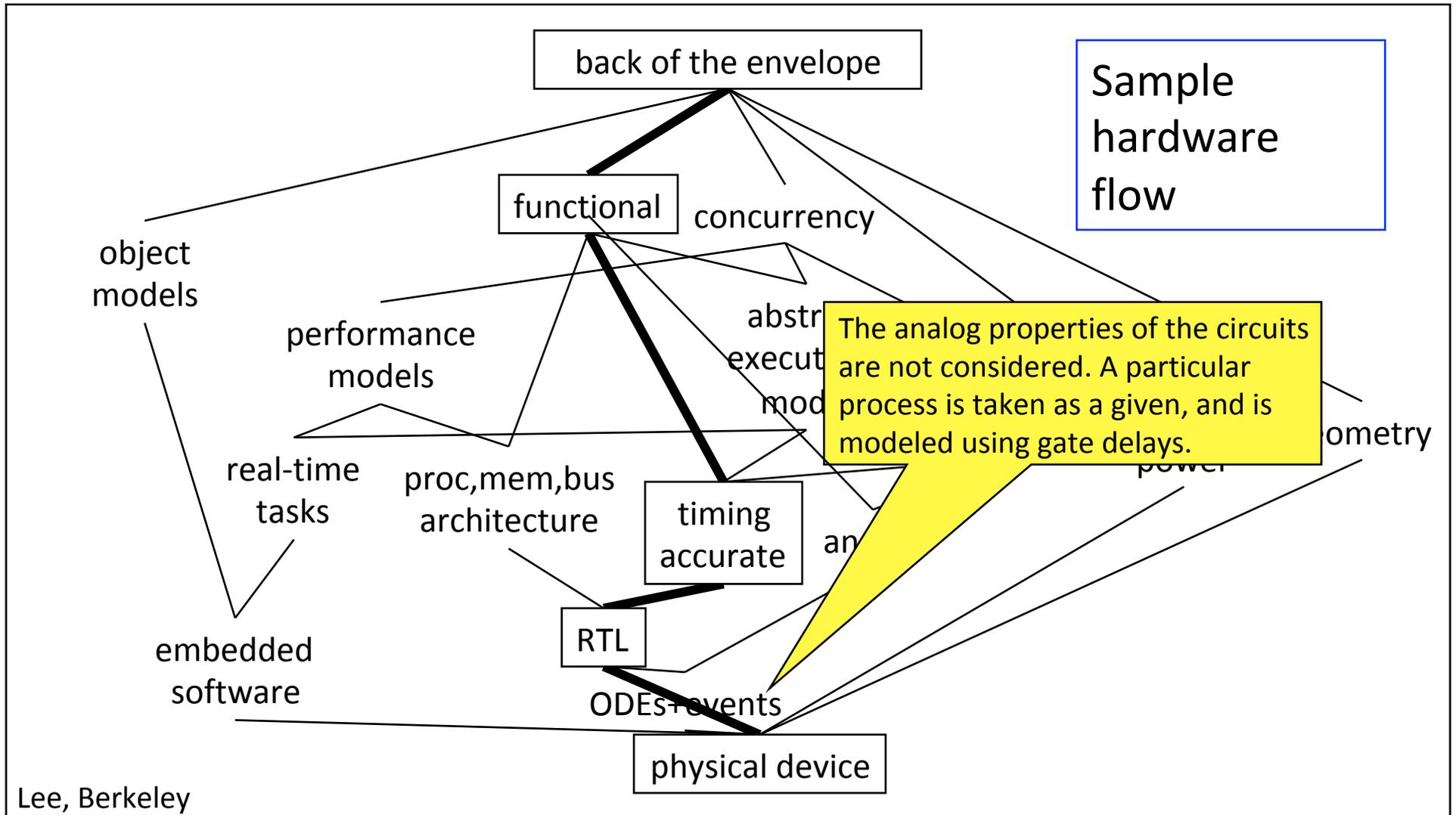


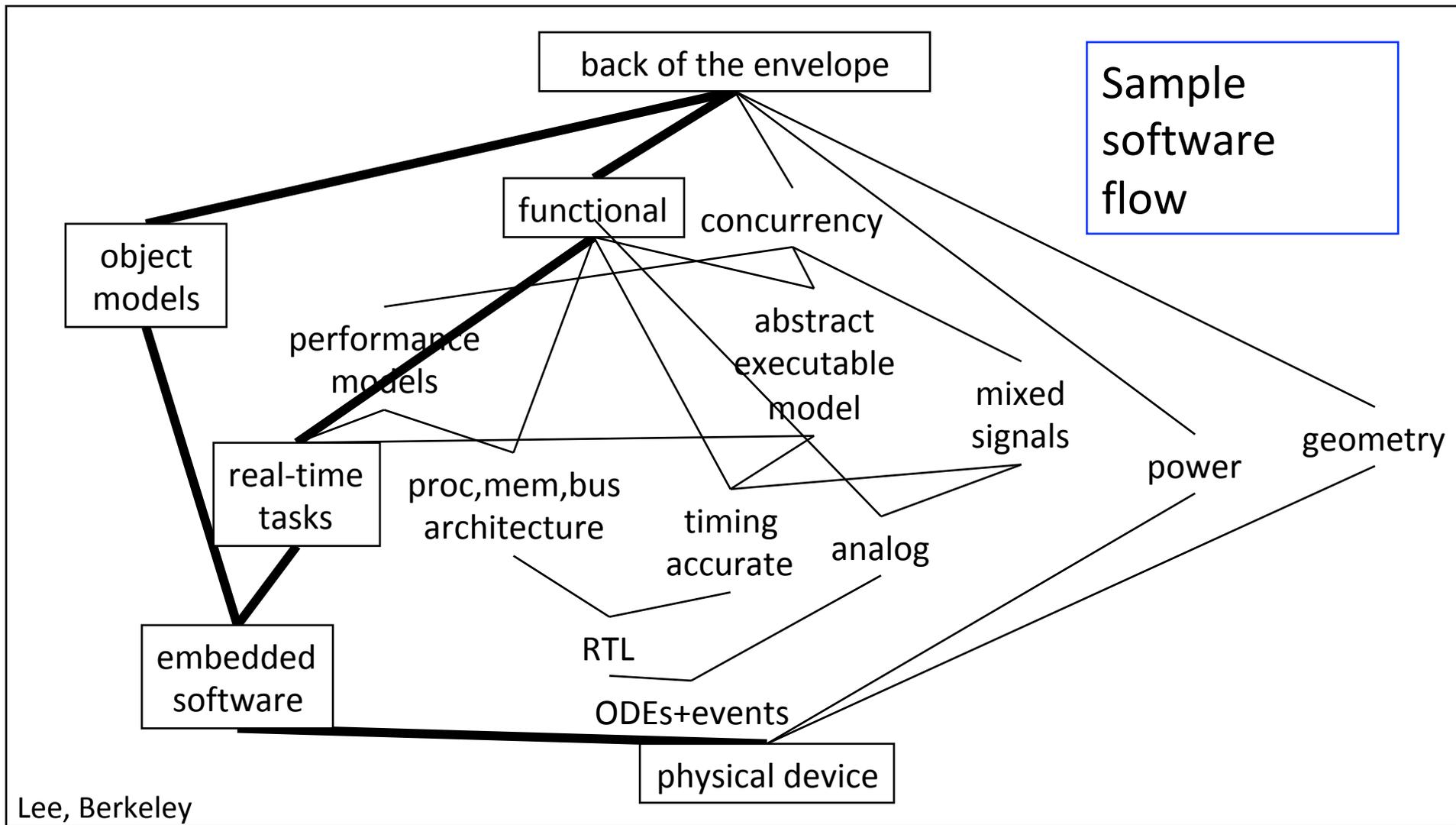




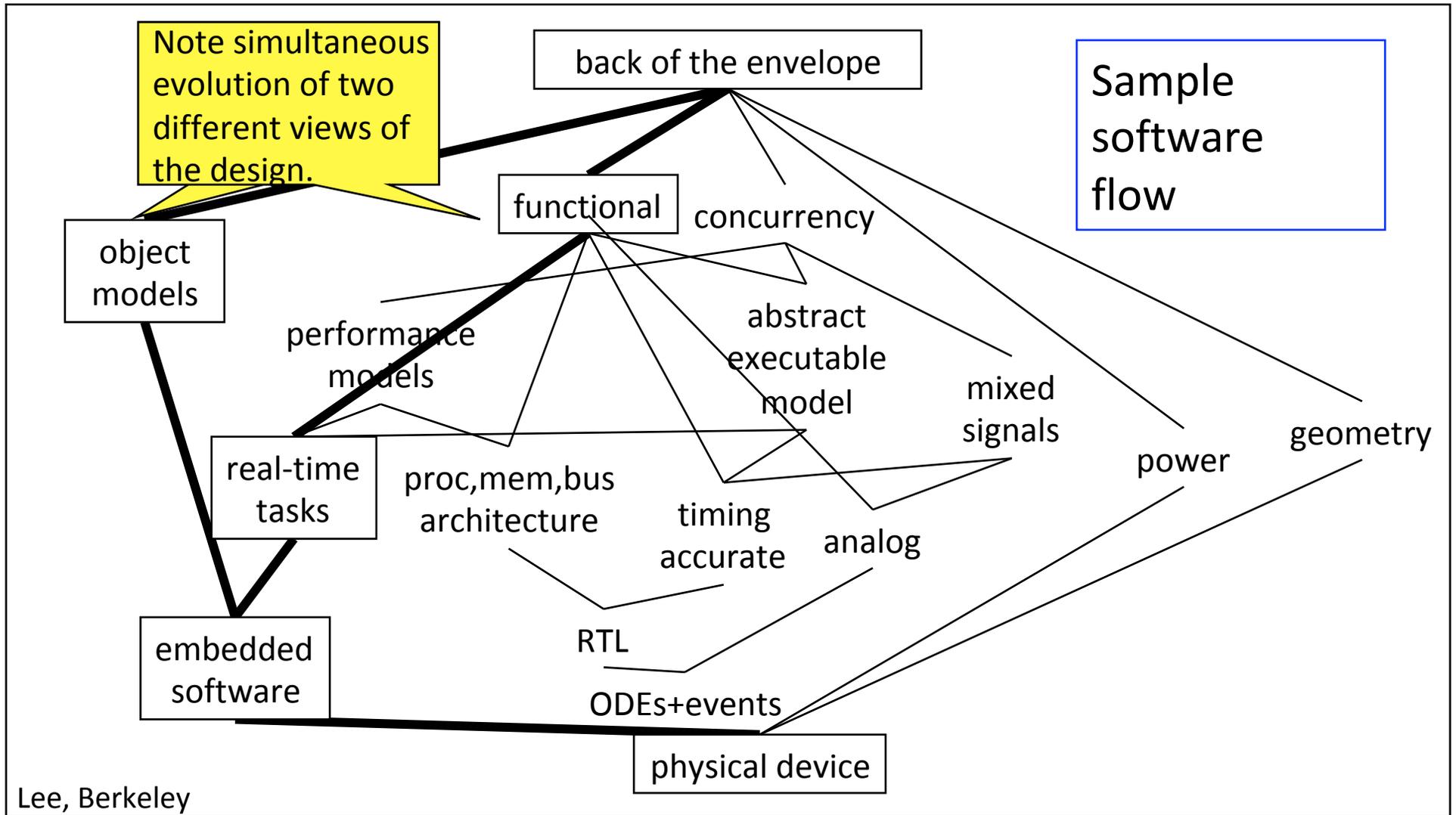




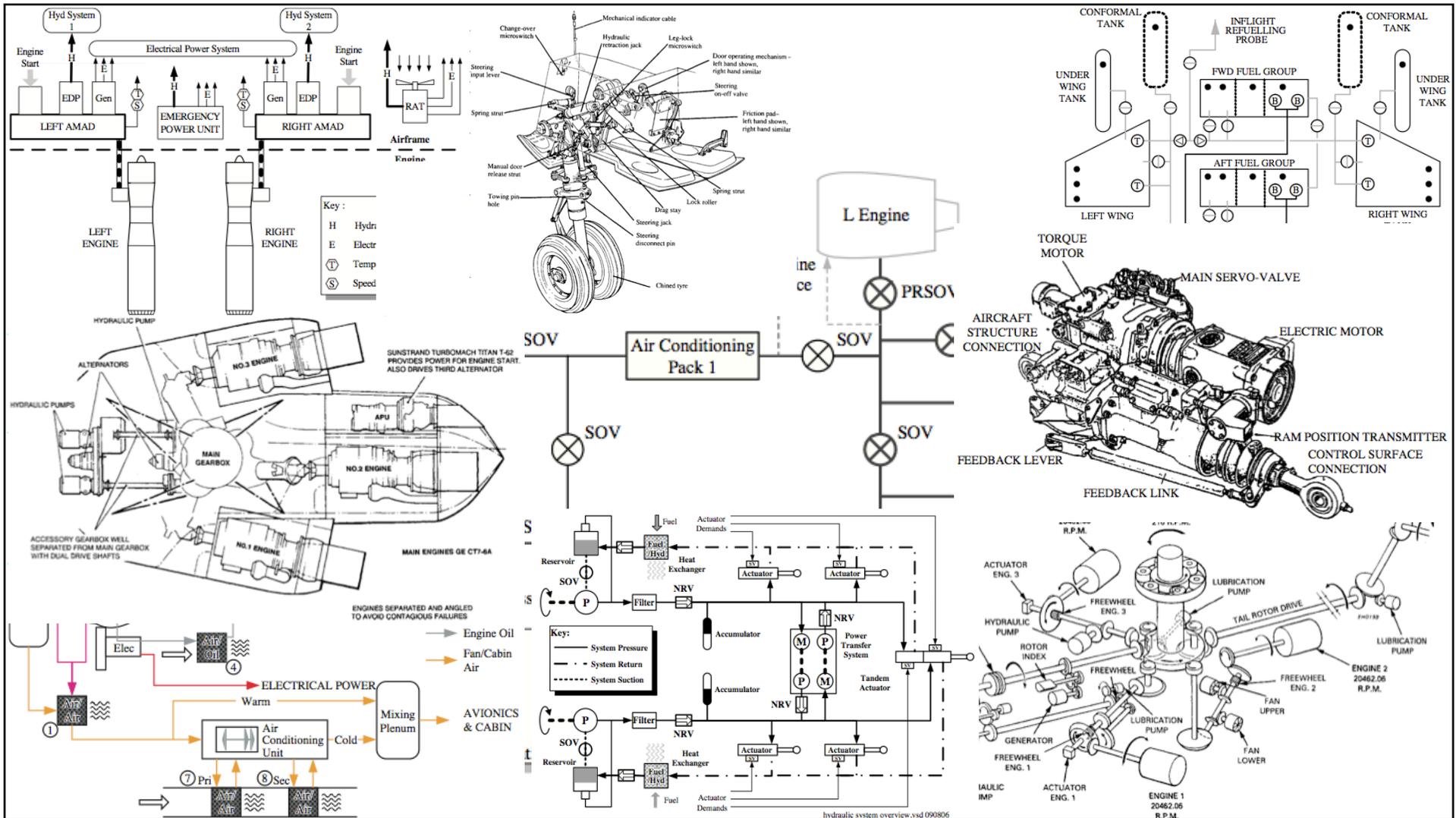


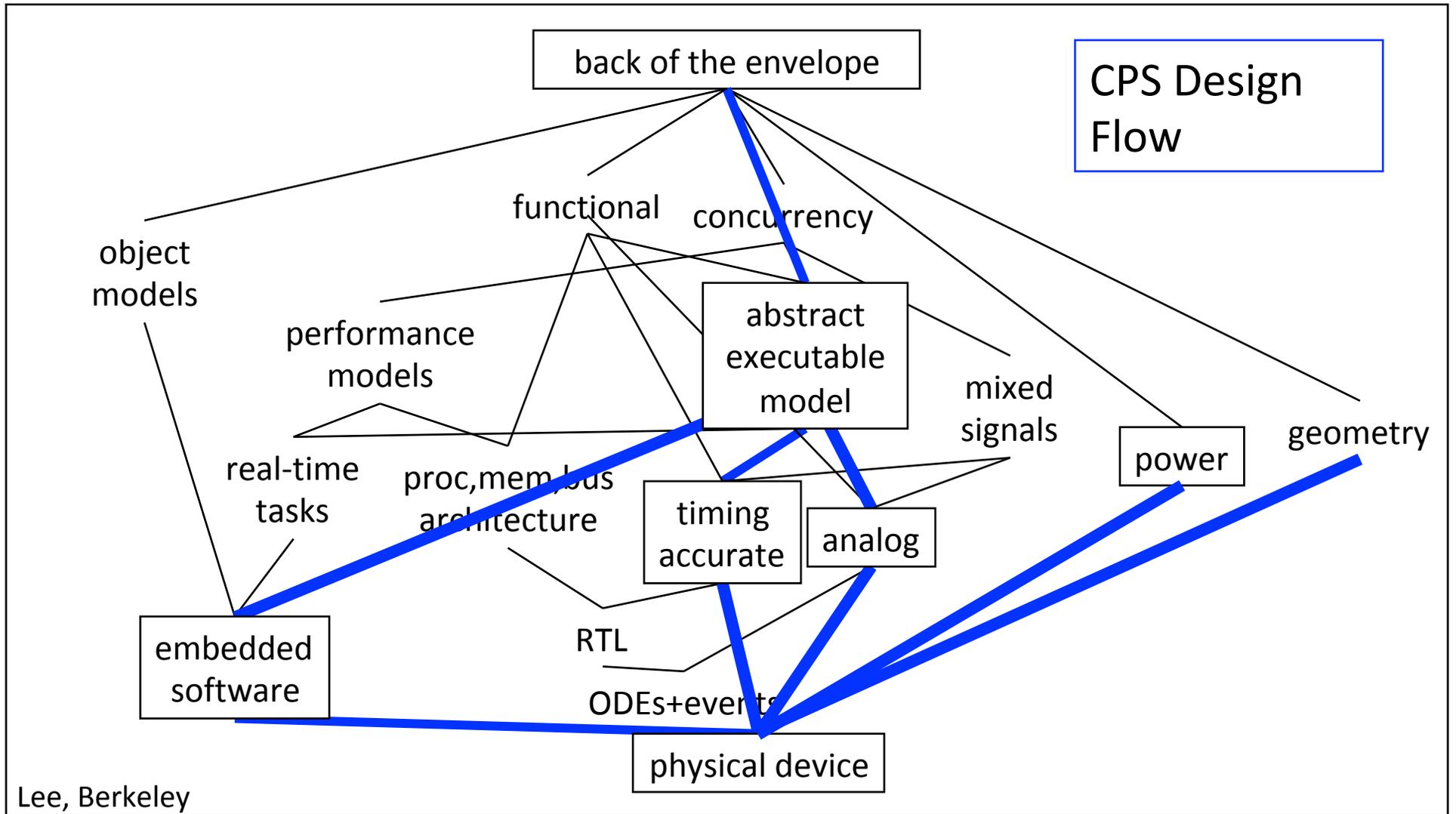


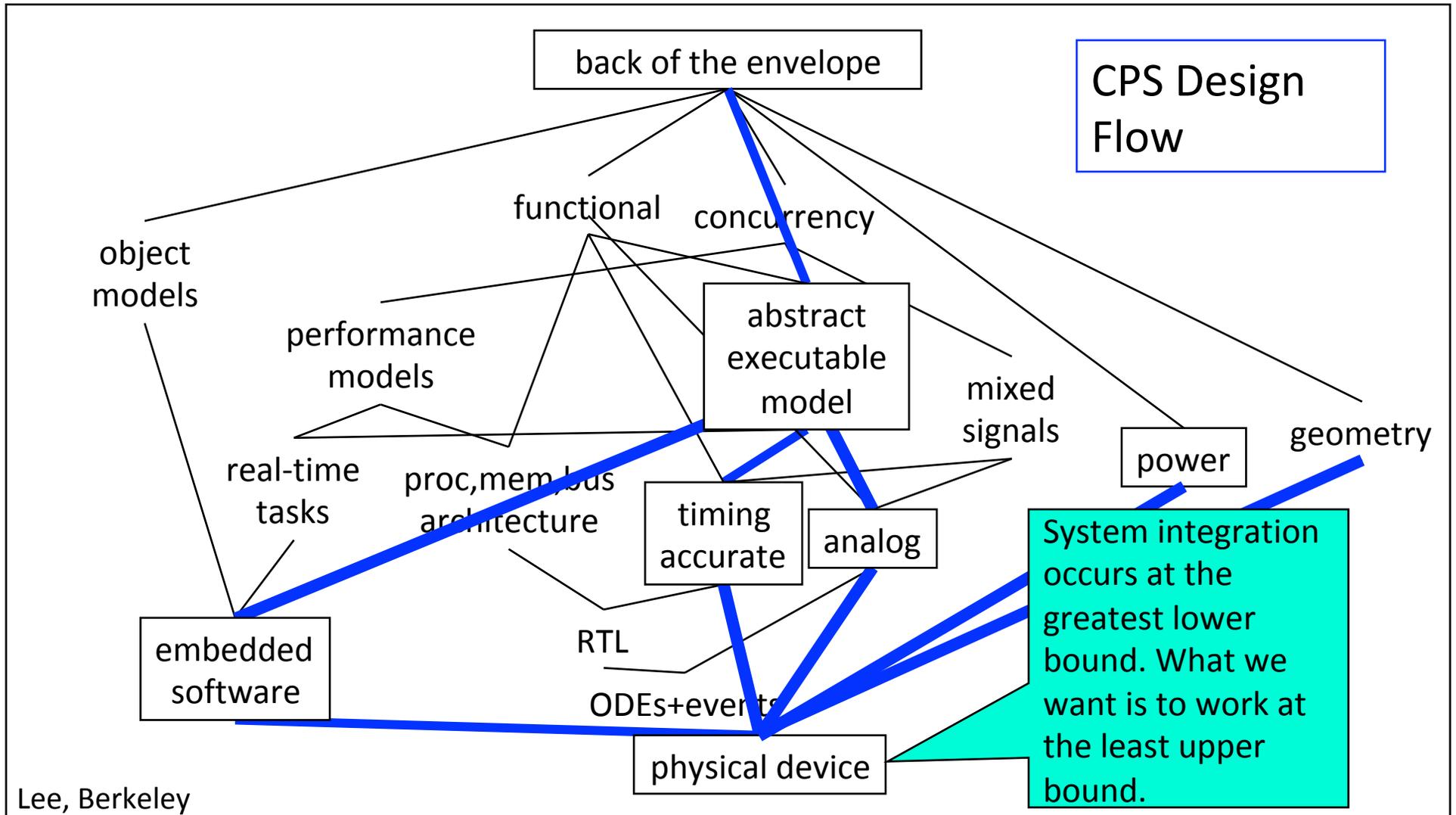
Lee, Berkeley









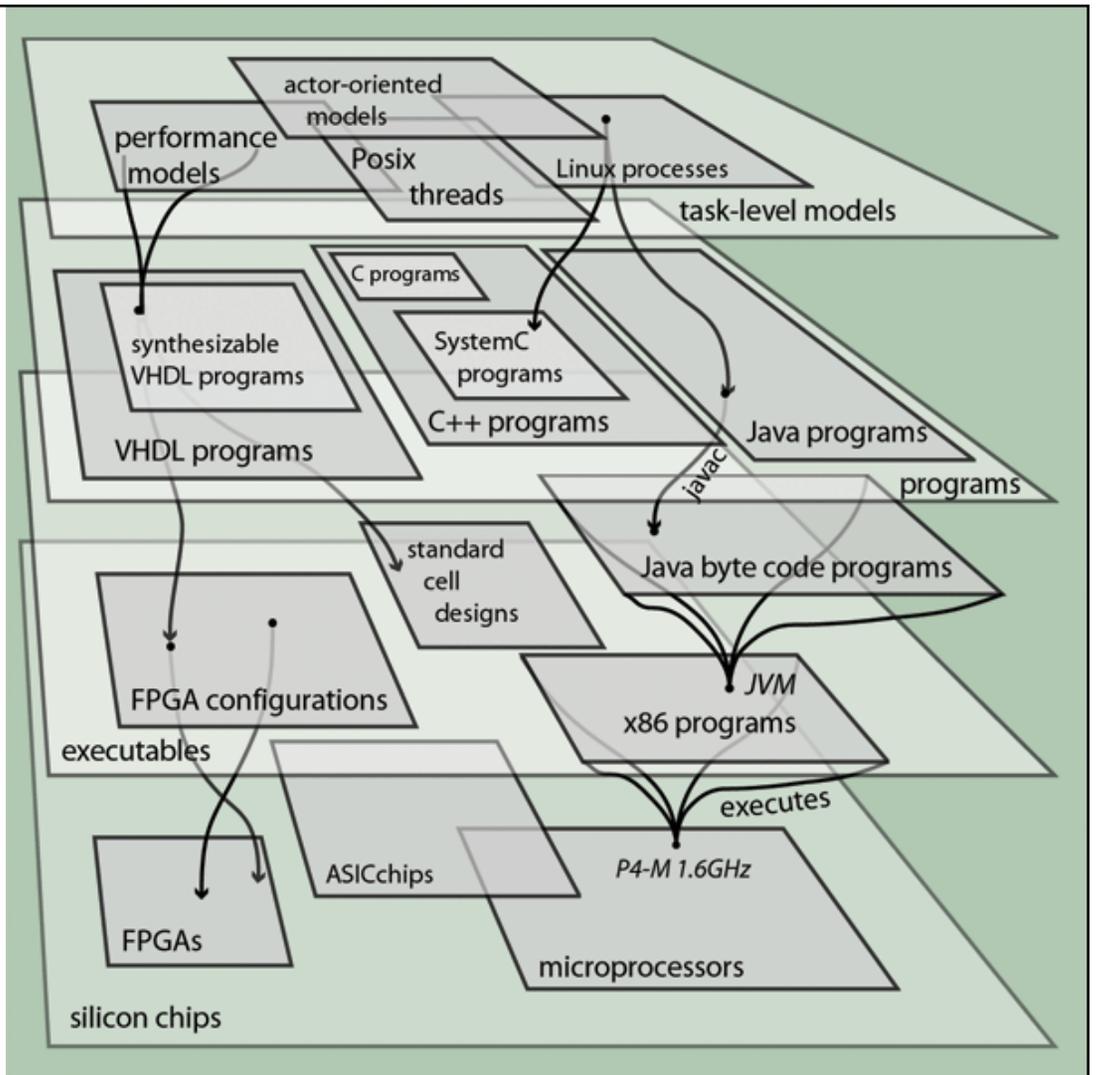


CPS Design Flow

System integration occurs at the greatest lower bound. What we want is to work at the least upper bound.

# Platforms

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

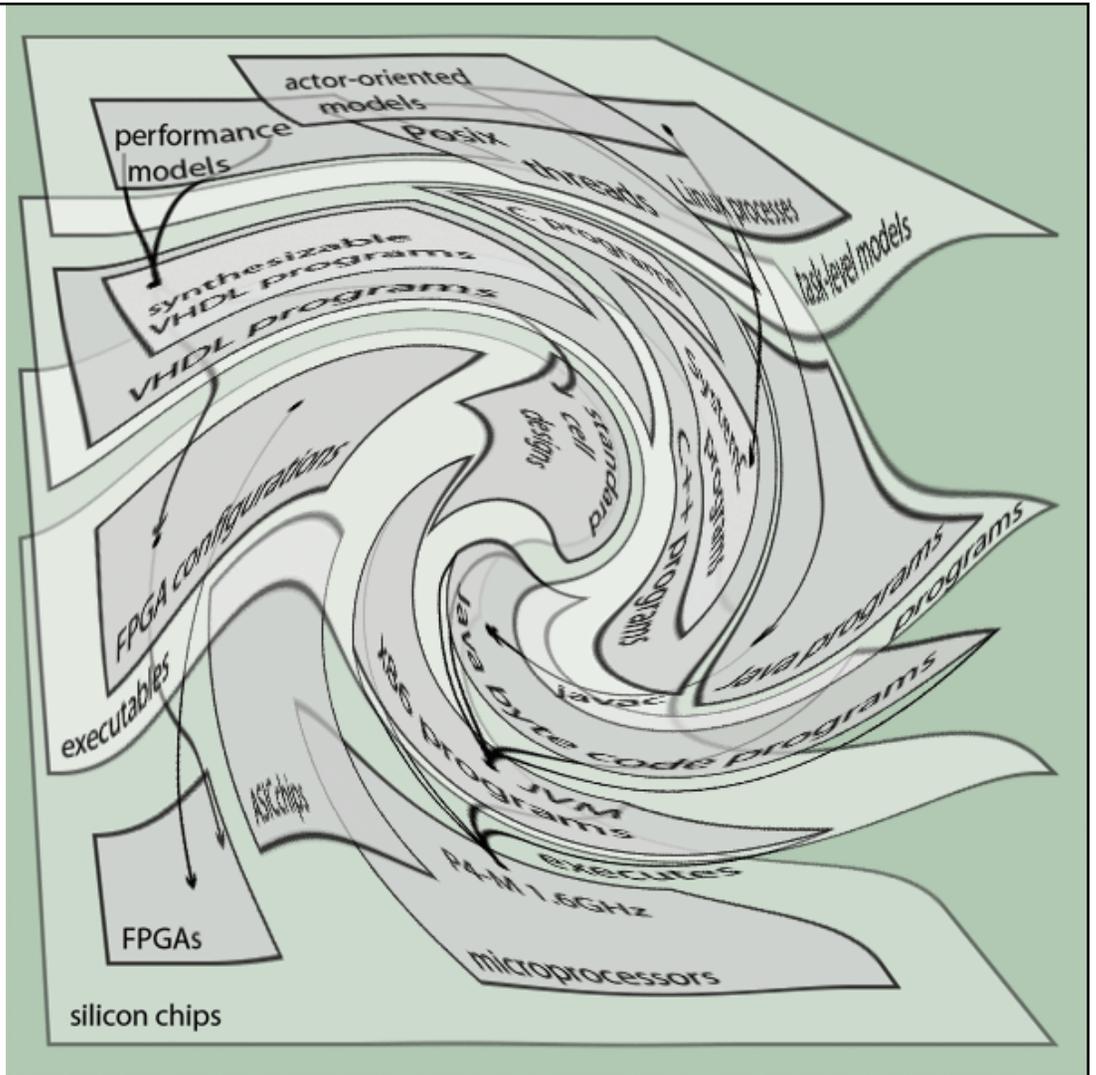


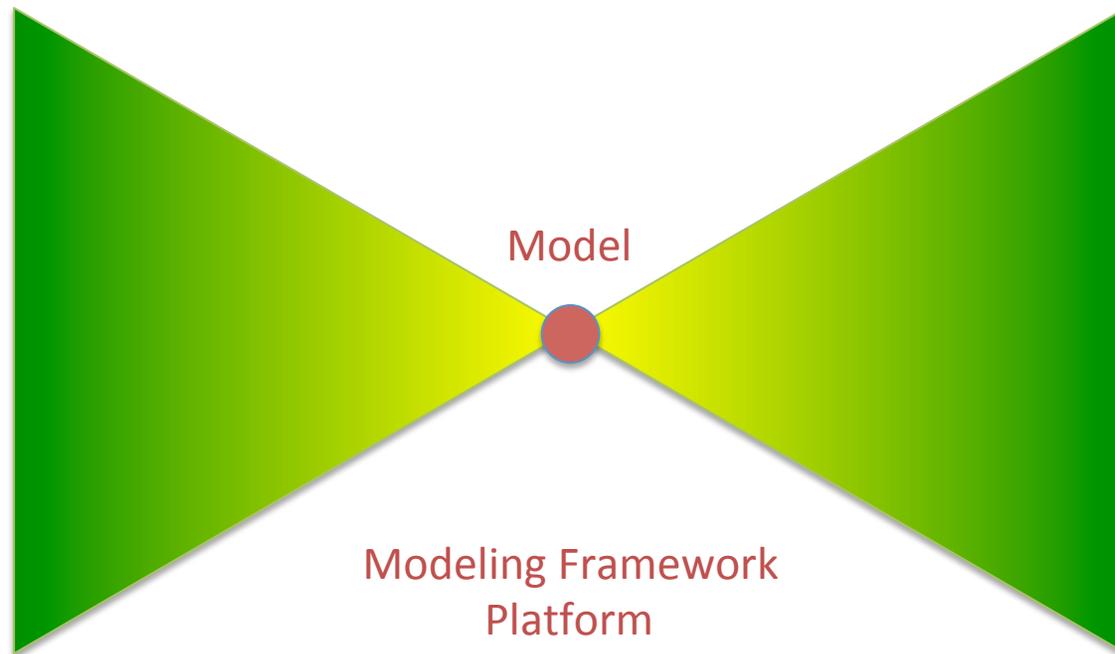


# Life Without Platforms

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

The design *is* the implementation.

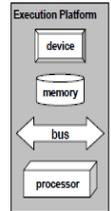




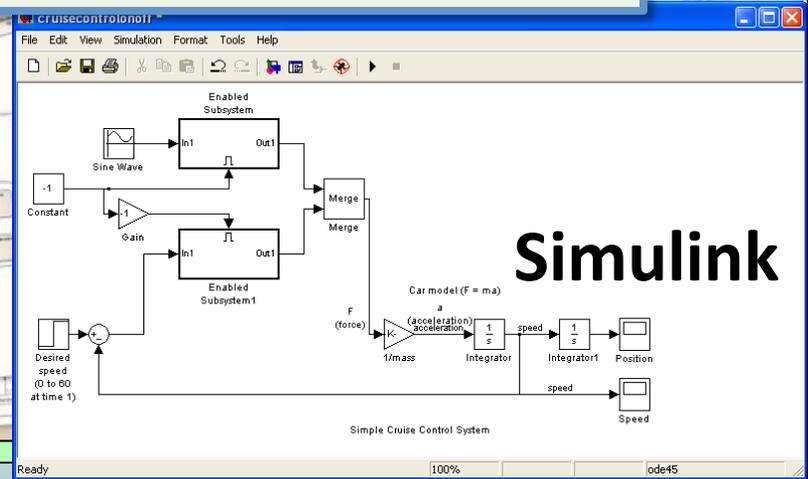
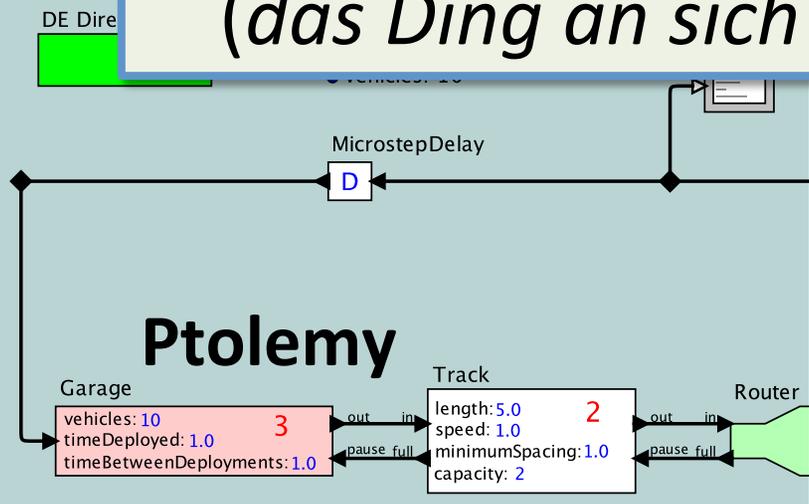
Model

Modeling Framework  
Platform  
"Freedom From Choice"

# What is a Model?



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



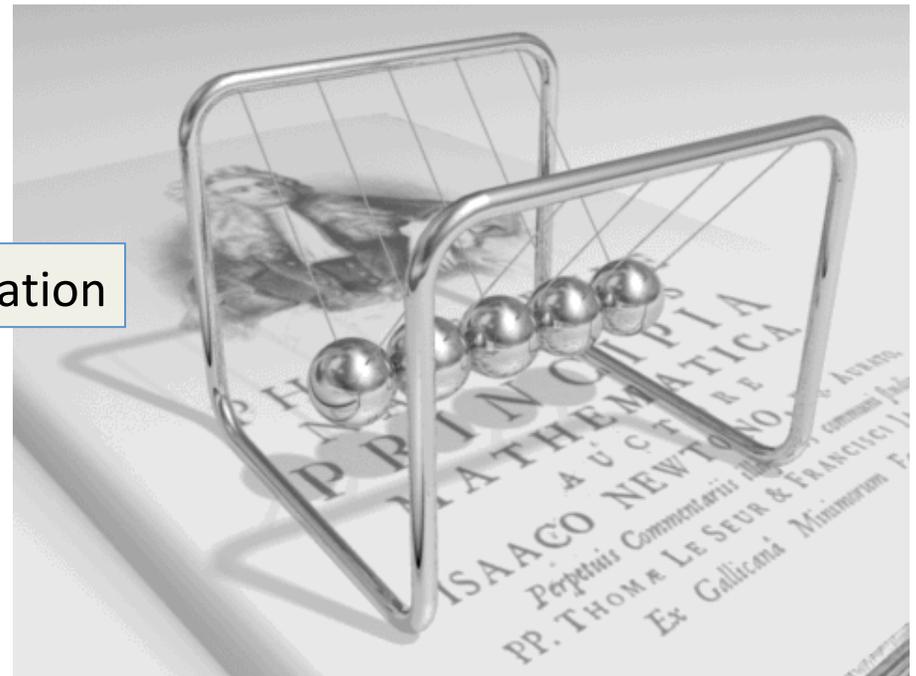
# A Modeling Framework

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

The model

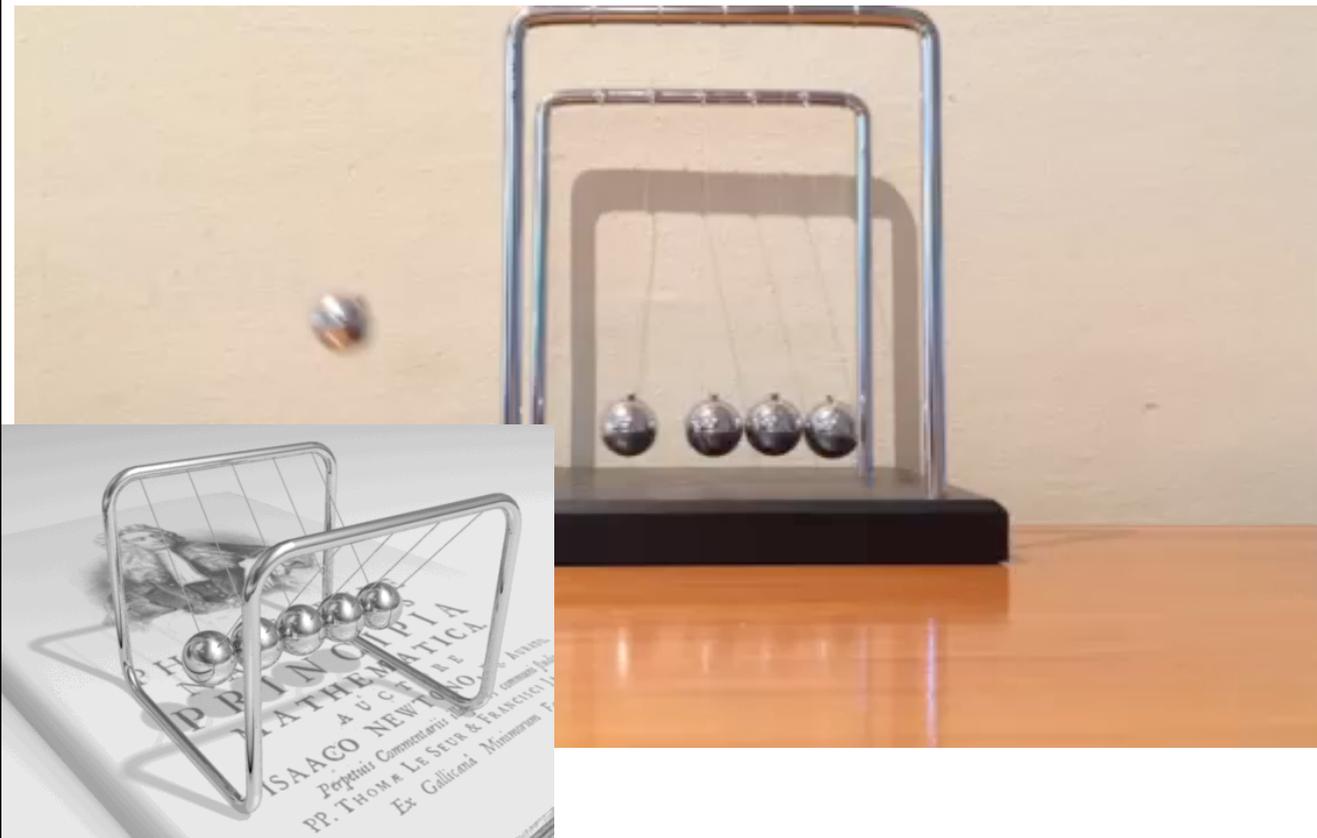
$$v(t) = v(0) + \frac{1}{m} \int_0^t F(\tau) d\tau.$$

Simulation



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

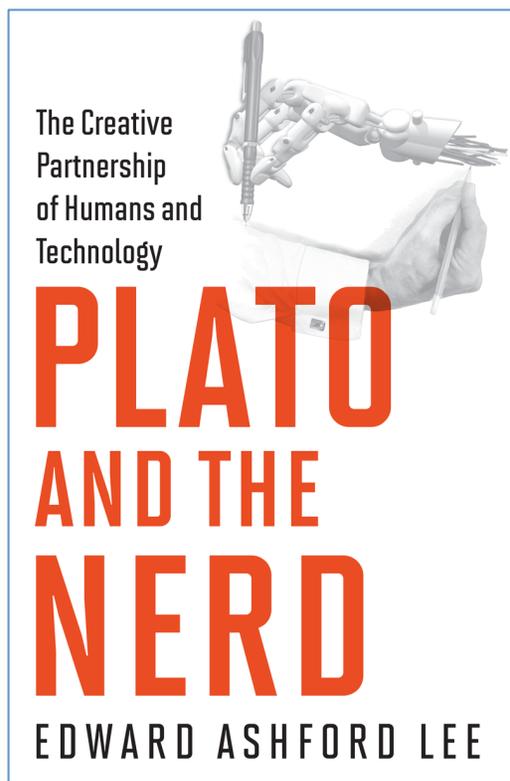
# The Map and the Territory



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

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

# An Epiphany



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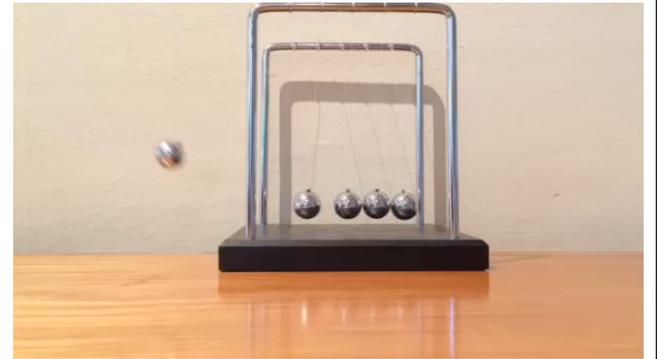
## The Value of Models

- 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...

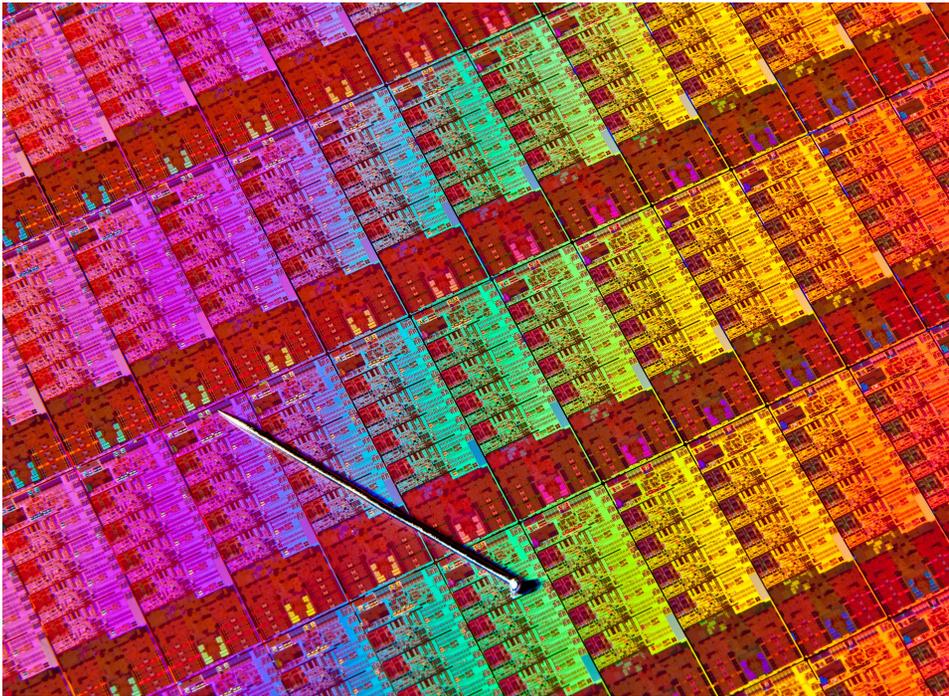
## Changing the Question

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



Intel Haswell, each with 1.4 billion transistors

Lee, Berkeley

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

## 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?



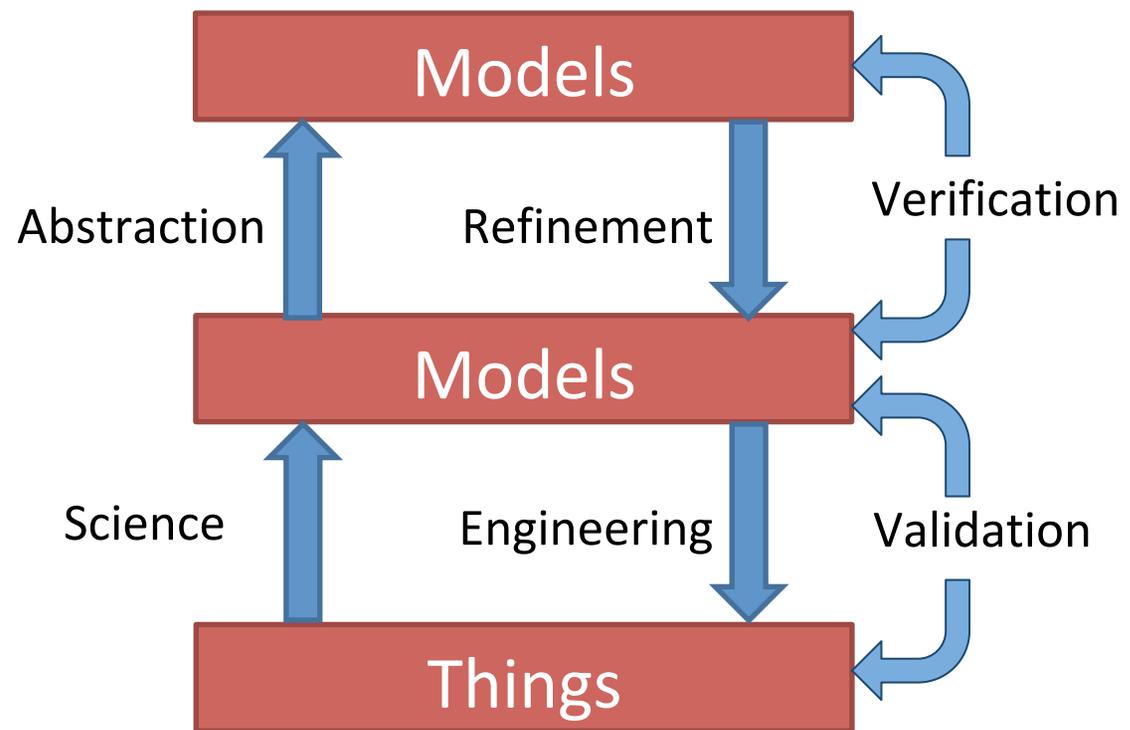
**Figure 1: Three scenes generated from a single ~20-line SCENIC scenario representing bumper-to-bumper traffic.**

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

# 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

