Freedom From Choice and the Power of Models: in Honor of Alberto Sangiovanni-Vincentelli

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ABSTRACT

Discovery, invention, and design are all about models. When we say "Joseph Priestly discovered oxygen in 1774," we do not mean that Priestly dug up a canister of oxygen, recognized it as something new, and released it, for the first time, into the air. We mean instead that Priestly came up with a model for the composition of air and the role of one of its components. The model was the discovery, not the O_2 molecule. Models in engineering and science are strongly affected by the modeling paradigm within which a model is constructed. Priestly's paradigm was firmly rooted in a theory of phlogiston, a fire-like element released in combustion, and his inability to break out of this rut made his work more like idiosyncratic philosophy than like science. The constraints of a modeling paradigm can be debilitating, but at the same time, they are essential. The constraints define the "platform" in "platform-based design" [2]. No effective modeling paradigm lacks constraints, and those constraints do not just limit our thinking, they also enable our thinking. In engineering, constraints are even more important because models that cannot be turned into real, working systems are not useful models. Whereas in science the value of a model lies in how well it matches a pre-existing physical system, in engineering, the value of a manufactured physical system lies in how well it matches a model [1]. Sangiovanni-Vincetelli has pointed out that modeling constraints provide a "freedom from choice" that makes it easier to build models for which we can create matching physical realizations. Because of this, engineers strive to grow the number of relevant modeling paradigms, those for which we can build effective physical realizations, whereas scientists strive to shrink the number of relevant paradigms, those needed to explain the physical world.

CCS CONCEPTS

• **General and reference → General literature**;

KEYWORDS

modeling, platform-based design

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1 BIOGRAPHY

Edward A. Lee is Professor of the Graduate School in EECS at UC Berkeley. He is the author of several books and more than 300 papers and has delivered more than 180 keynote and other invited talks at venues worldwide. Lee's research focuses on cyber-physical systems, which integrate physical dynamics with software and networks. His focus is on the use of deterministic models as a central part of the engineering toolkit for such systems. He is the director of iCyPhy, the Berkeley Industrial Cyber-Physical Systems Research Center. From 2005-2008, he served as chair of the EE Division and then chair of the EECS Department at UC Berkeley. He led the development of several influential open-source software packages, notably Ptolemy and its spinoffs. His degrees are from Yale (BS), MIT (SM), and Berkeley (PhD). From 1979 to 1982 he was a member of technical staff at Bell Labs in Holmdel, New Jersey. He is a co-founder of BDTI, Inc. and has consulted for a number of other companies. He is a Fellow of the IEEE, was an NSF Presidential Young Investigator, won the 1997 Frederick Emmons Terman Award for Engineering Education, received the 2016 Outstanding Technical Achievement and Leadership Award from the IEEE Technical Committee on Real-Time Systems (TCRTS) and The Berkeley Citation in 2018.

Photo by Rusi Mchedlishvili

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