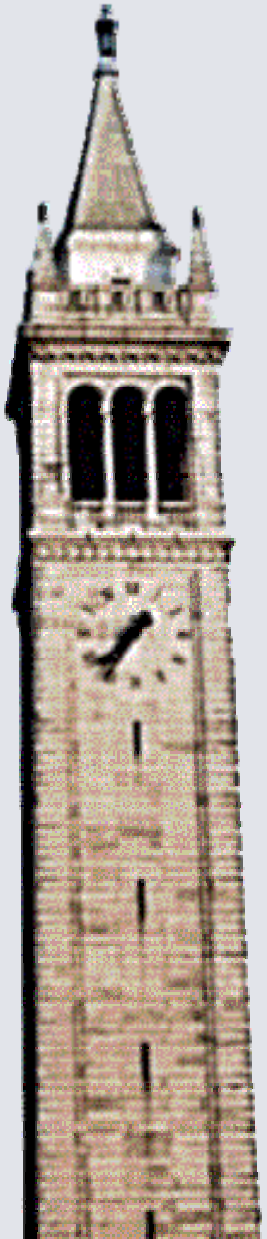
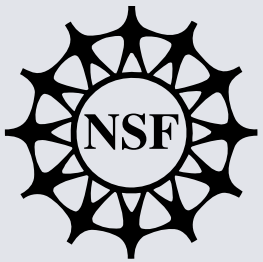
Educating a New Generation of Students in Embedded Systems

Edited and presented by
Edward A. Lee
Chair of EECS, UC Berkeley





Chess Review
October 4, 2006
Alexandria, VA

Statement of Principles

Although computer-based embedded systems have been designed for more than 30 years, they have only recently emerged as an intellectual discipline distinct from the applications and distinct from both hardware and software technologies.

The embedded revolution requires a reexamination—and often a reinvention—of core abstractions of computing and systems engineering. All effective abstractions hide properties of the underlying systems, but the key to their effectiveness is that they hide the right properties. The core abstractions of computing, for example, do not include time, yet embedded computing systems depend critically on predictable timing. Engineering education and research needs to anticipate, shape, and guide this transformation. This has to be done through a partnership that includes specialists in computing, electrical engineering, and the application domains such as scientific instrumentation, manufacturing systems, automotive electronics, etc.

The Goal

To create an integrated curriculum on computational systems theory and systems design practice with

- Concurrency
- Composability
- Time
- Modularity
- Security
- Heterogeneity
- Verifiability
- Understandability

This systems theory must be at once computational and physical.

The Challenge

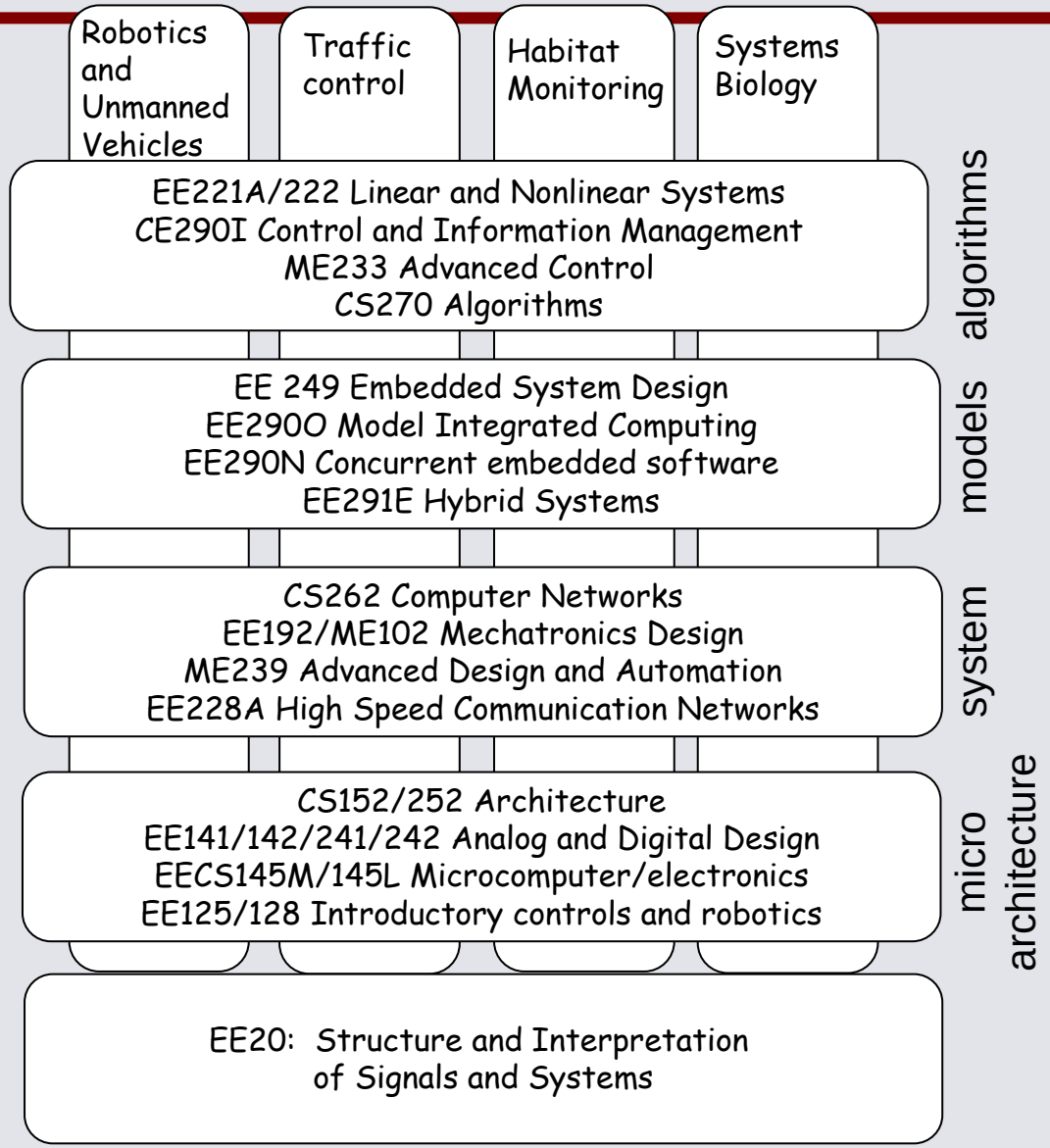
Models for the physical world and for computation diverge.

- physical: time continuum, ODEs, dynamics
- computational: a "procedural epistemology," logic

There is a huge cultural gap.

Physical system models must be viewed as semantic frameworks, and theories of computation must be viewed as alternative ways of talking about dynamics.

Research and Education at Berkeley



Large research projects (e.g. PATH, GSRC, CHESS)

Advanced courses (290 series)

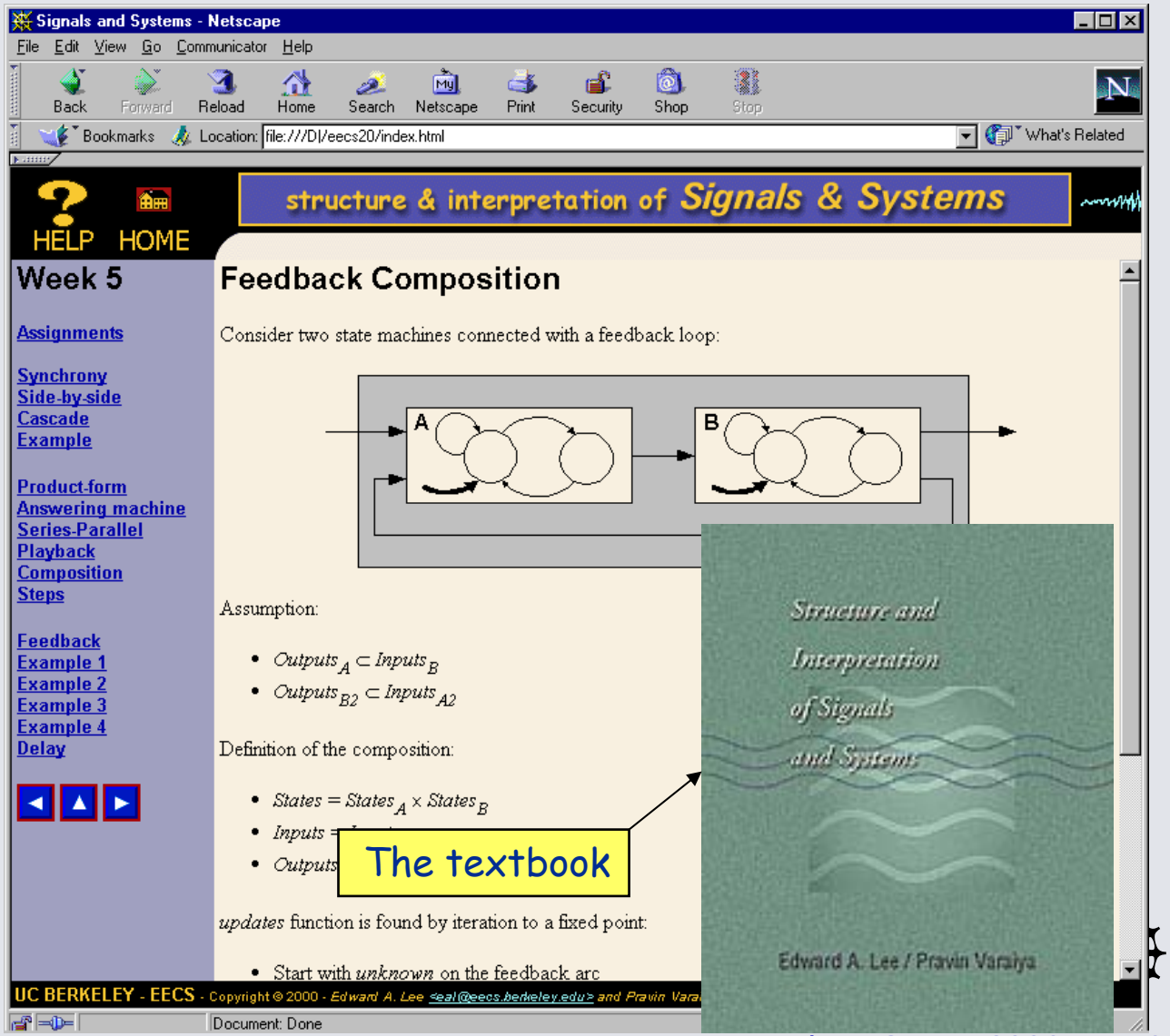
Graduate courses (e.g. EE249: Embedded System Design: Modeling, Validation and Synthesis)

Undergraduate courses (e.g. EE20: Structure and Interpretation of Signals and Systems)

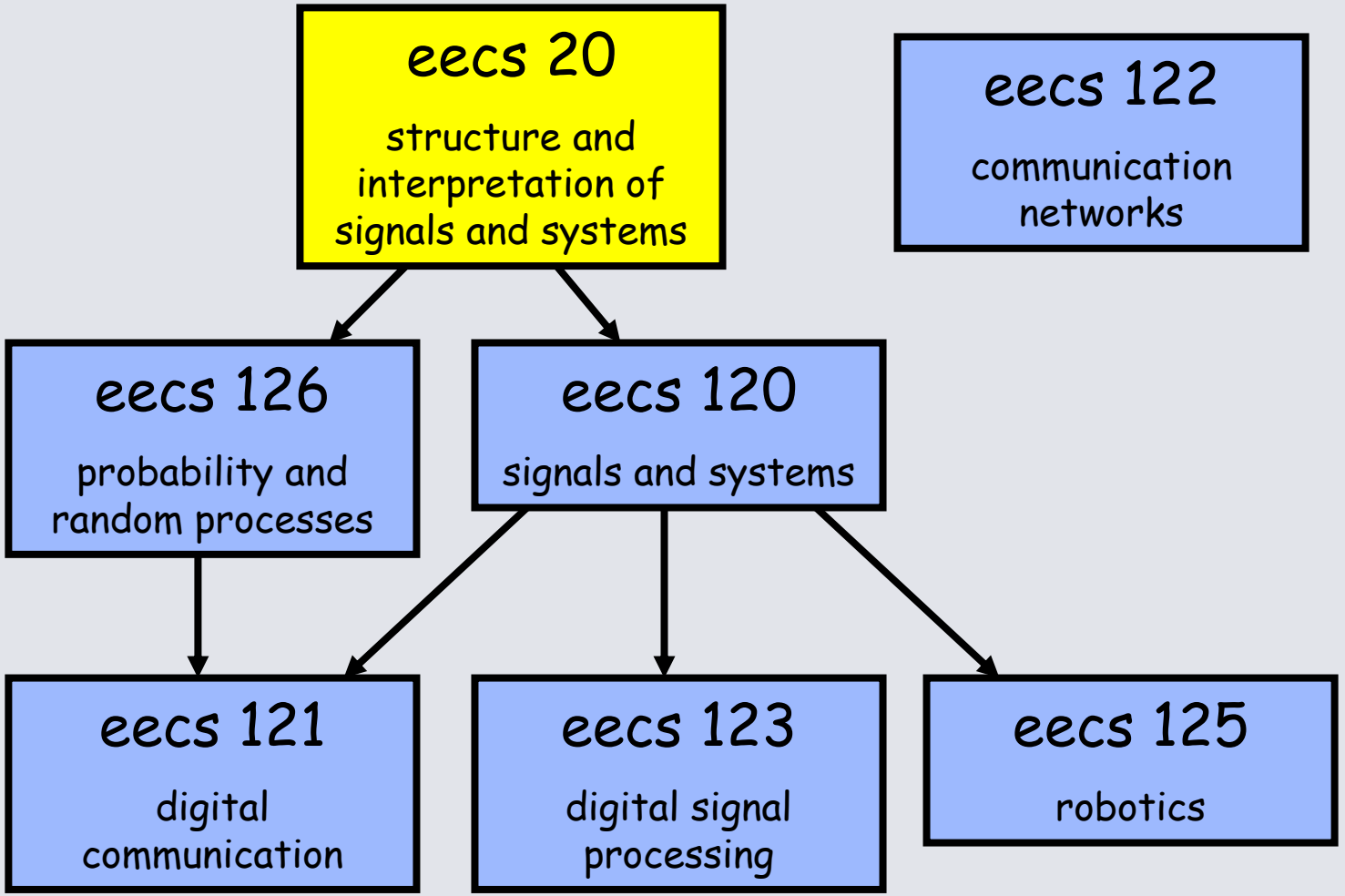
Build on our Introductory Course on Computational Signals and Systems

Berkeley has a required sophomore course for EE and CS students that addresses mathematical modeling of signals and systems from a computational perspective.

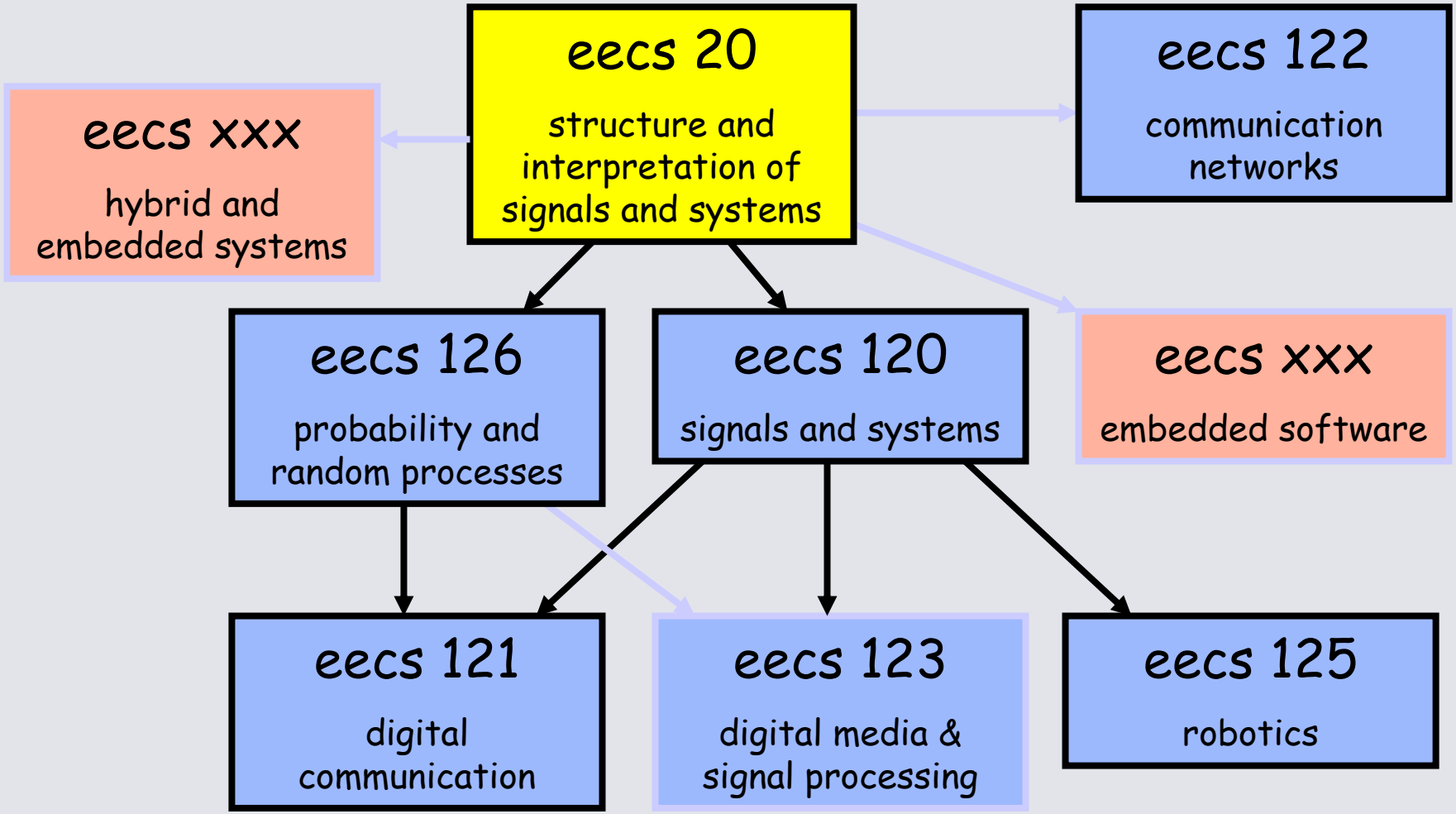
The web page at the right illustrates a broad view of feedback, where the behavior is a fixed point solution to a set of equations. This view covers both traditional continuous feedback and discrete-event systems.



Current Role in EECS, Undergrad

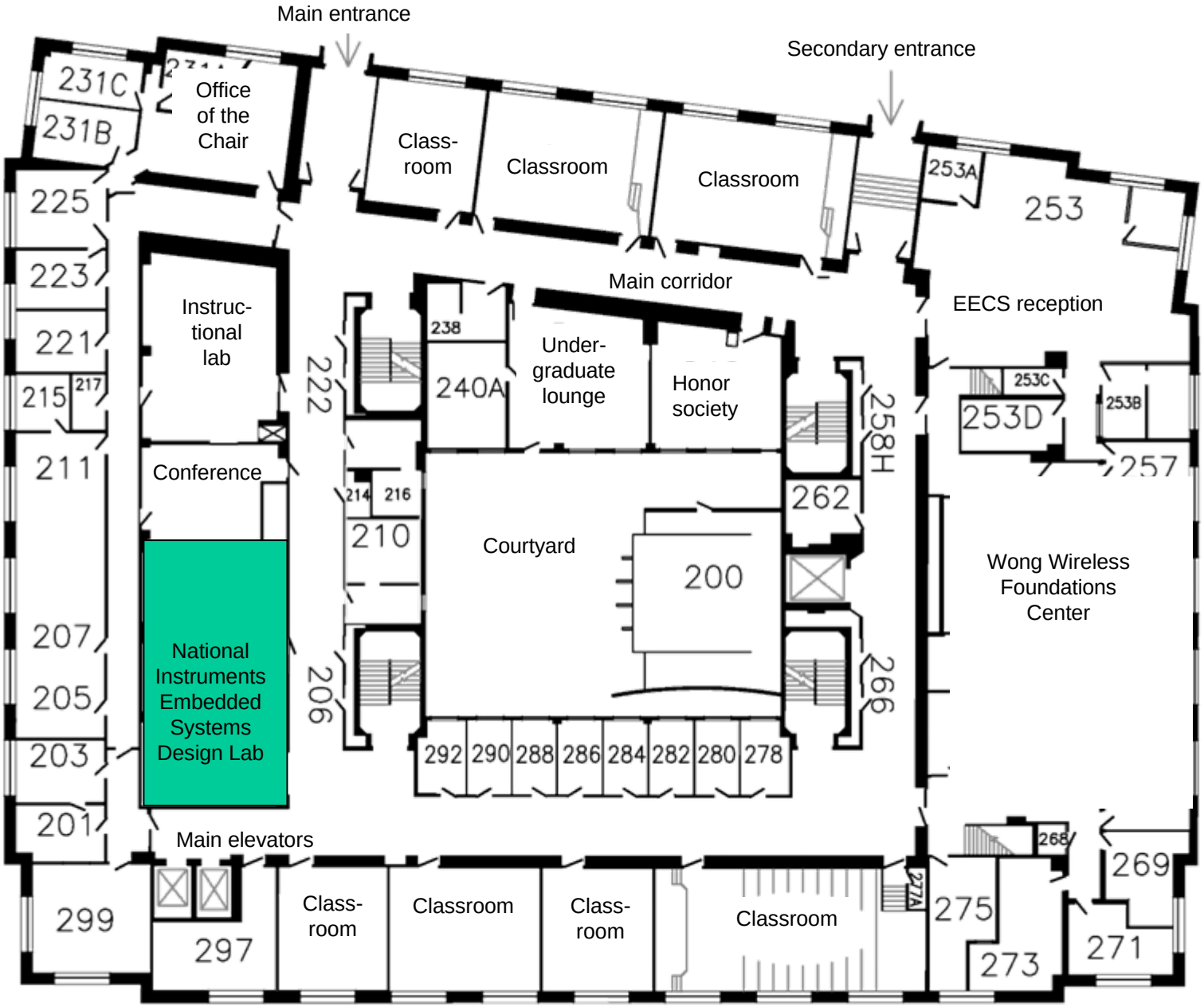


Future Role in EECS Undergrad



The EECS Department Commitment

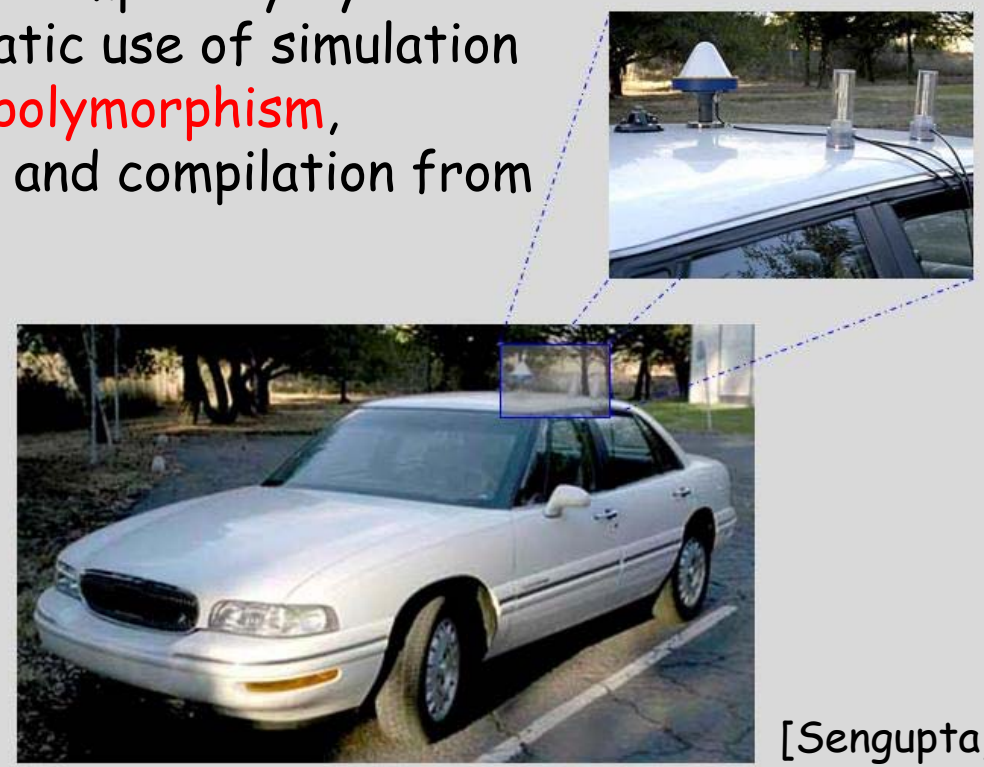
- Has secured $1.5M for facilities, $0.5M for equipment for an embedded systems design lab.
- Will make embedded systems a priority area for faculty hiring.
- Will commit resources to course development and instruction.
- Will work with other College of Engineering departments for maximum leverage.
- Will re-examine the curriculum for appropriate math, statistics, and computing requirements.
- Will coordinate with outside leaders at peer institutions worldwide.



2nd Floor - Cory Hall

Outreach to the College of Engineering
E.g.: CE290I: Control & Information Mgmt

Mathematical methods and information technologies for controlling CEE systems. Emphasizes designing component organizations that interact with the world in real-time to control a large system. Methods applied to transportation operations, supply chains, and structures. Management of design complexity by hierarchical specification, systematic use of simulation and verification tools, semantics, polymorphism, information management services, and compilation from high-level design languages.



[Sengupta]

Why Should We Lead The Way?

- We have long track record of shaping and defining the core of the standard curriculum in several engineering specialties.
- We represent the strongest research programs in embedded systems:
  - wireless sensor networks
  - model-based design
  - embedded software
  - configurable hardware
  - hybrid systems modeling
  - bio-mimetic systems
  - wireless communications systems
  - power-aware systems
- Our partners in the College of Engineering have world-class research programs in manufacturing systems, automotive electronics, process control, mechatronics, transportation systems, and eco-systems.

Involved Faculty at Berkeley

- Dave Auslander, Mechanical Engineering
- Ahmad Bahai, Electrical Engineering
- Alex Bayen, Civil and Environmental Engineering
- Eric Brewer, Computer Science
- David Culler, Computer Science
- Stephen Derenzo, Electrical Engineering
- Ron Fearing, Electrical Engineering
- Karl Hedrick, Mechanical Engineering
- Hami Kazerooni, Mechanical Engineering
- Kurt Keutzer, Electrical Engineering
- Ali M Niknejad, Electrical Engineering
- Kris Pister, Electrical Engineering
- Jan Rabaey, Electrical Engineering
- Alberto Sangiovanni-Vincentelli, Electrical Engineering
- Shankar Sastry, Electrical Engineering
- Raja Sengupta, Civil and Environmental Engineering
- Sanjit Seshia, Electrical Engineering
- Claire Tomlin, Electrical Engineering
- John Wawrzynek, Computer Science