DPE First Friday Dinner Sponsored by Intel and ELI

The When, Why, What, Where, Who, How of Pursuing a Ph.D. in Engineering

Prof. Christopher Batten

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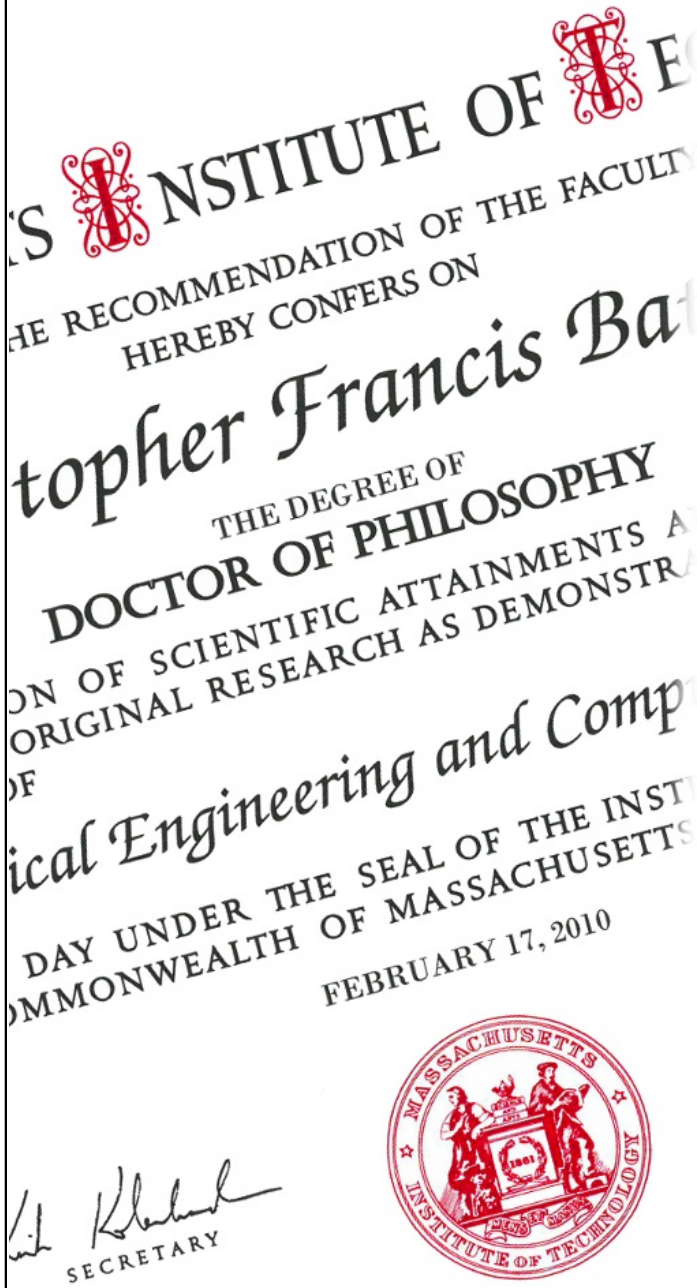
Spring 2013



Agenda

Personal Career Path

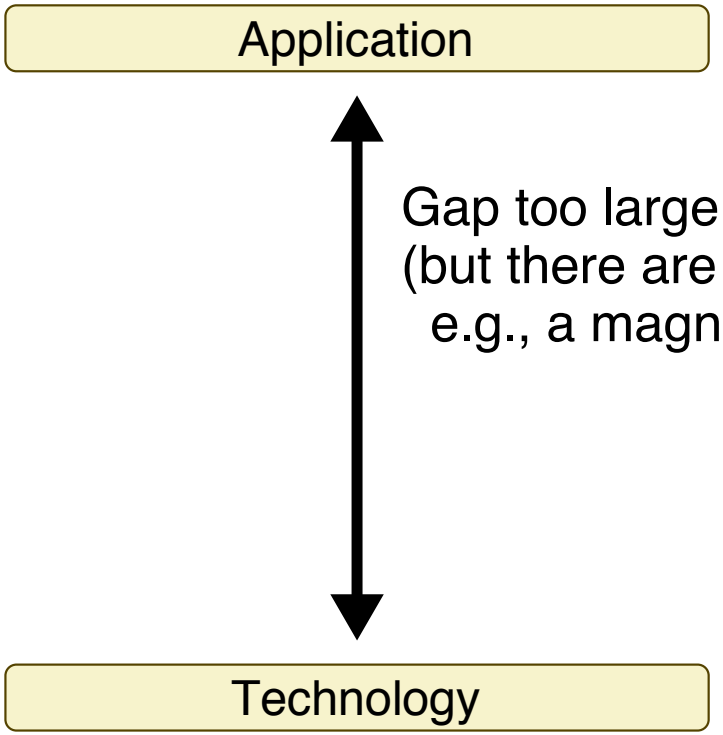
Research Overview

When, Why, What, Where, Who of Pursuing a Ph.D.

How to Succeed ...

- ... as an Undergraduate Researcher
- ... in Applying to Graduate School
- ... as a Graduate Student

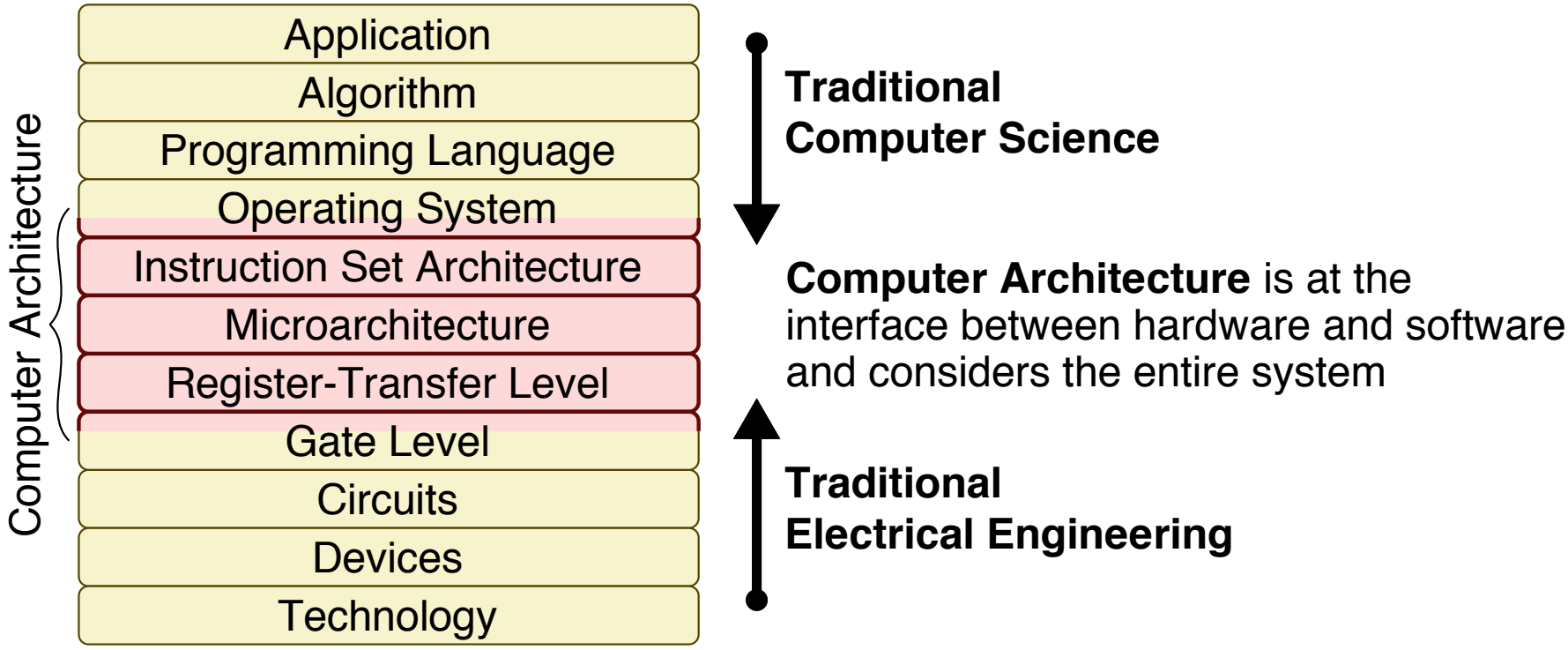
What is Computer Architecture?



Gap too large to bridge in one step
(but there are exceptions,
e.g., a magnetic compass)

In its broadest definition, computer architecture is the development of the abstraction/implementation layers that allow us to execute information processing applications efficiently using available manufacturing technologies

What is Computer Architecture?



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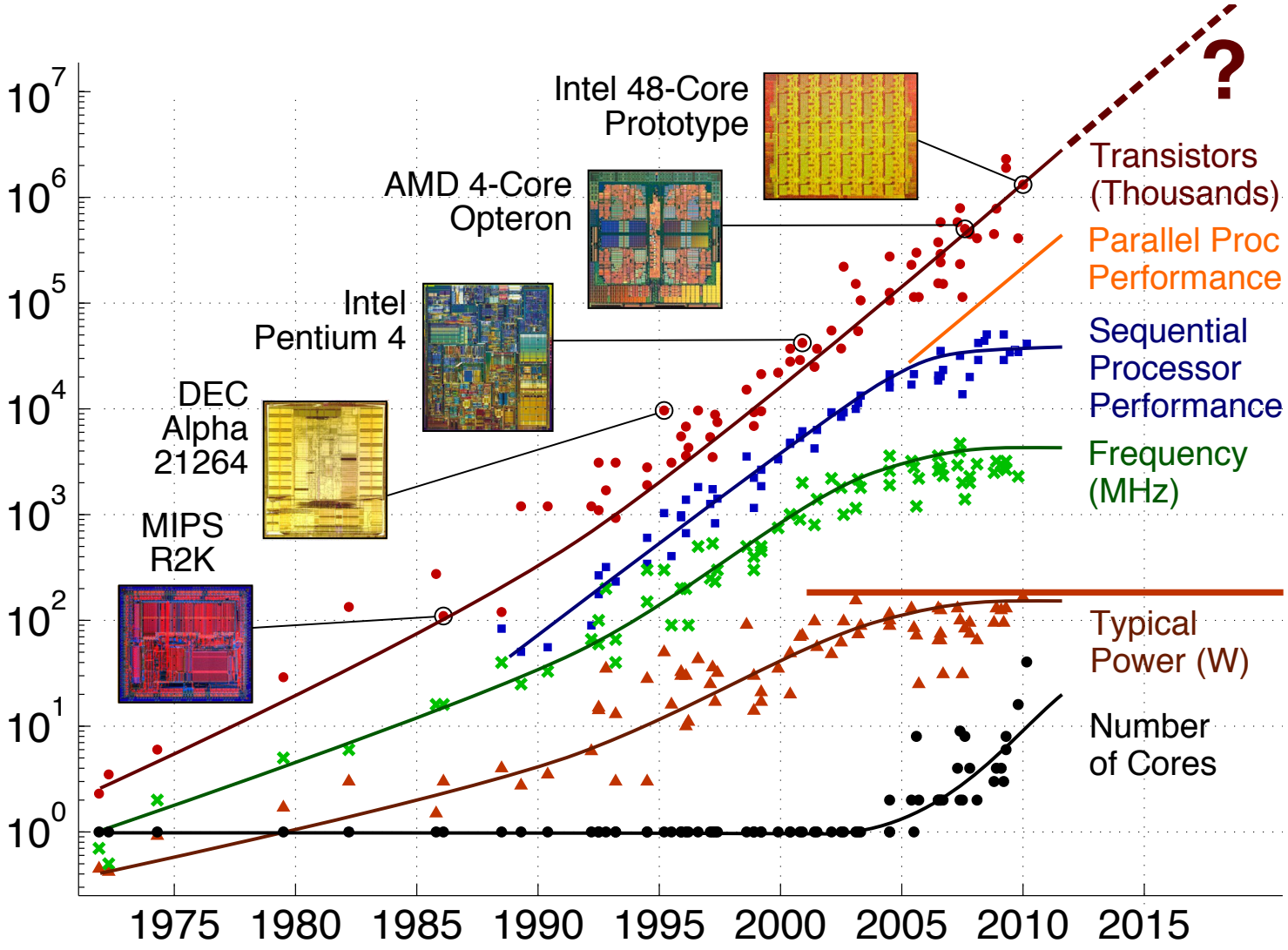
Motivating Trends in Computer Architecture



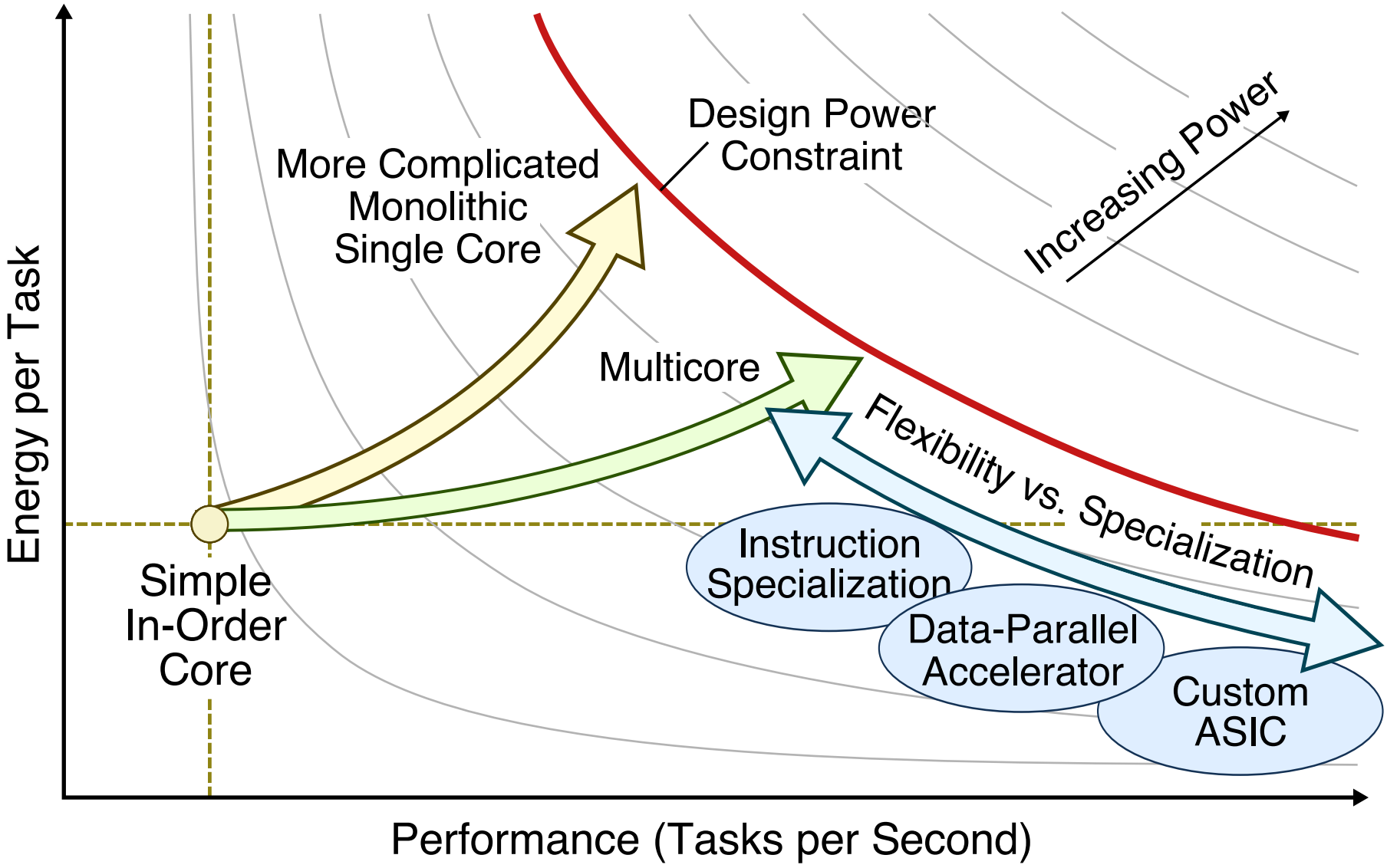
Data partially collected by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond

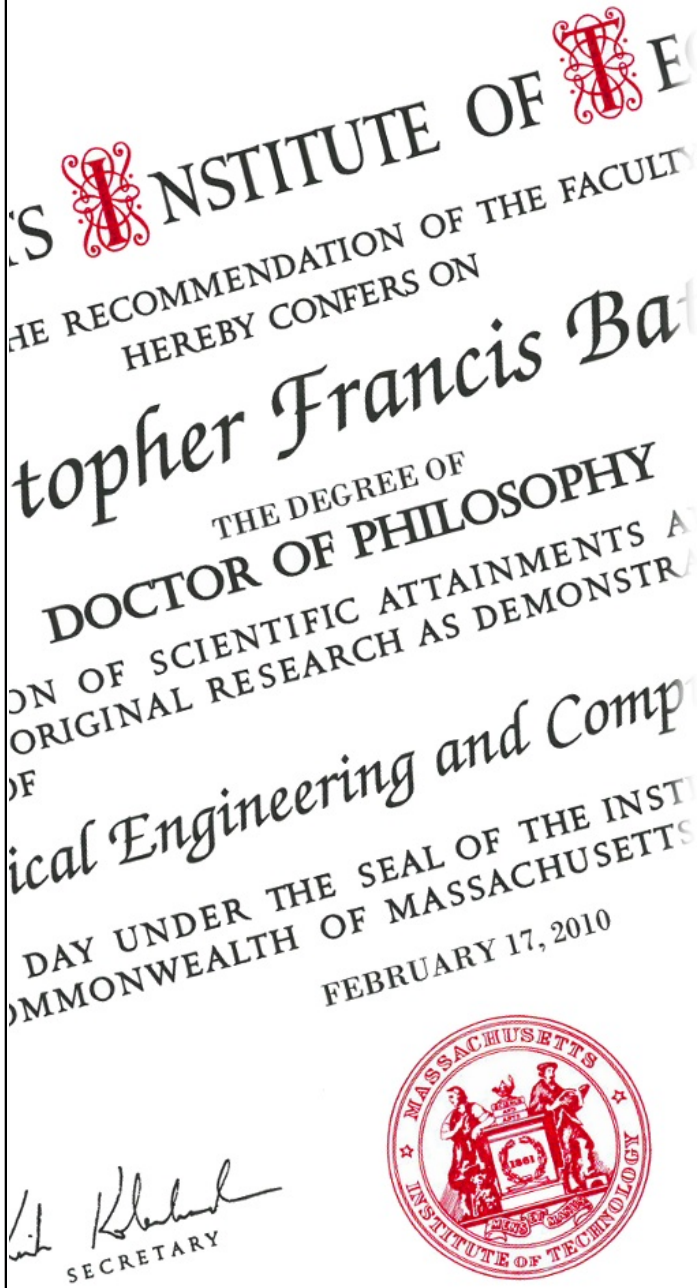
Trend 1
Power & energy constrain all systems

Trend 2
Transition to multicore processors

Trend 3
Inevitable end of Moore's law

Flexibility versus Specialization





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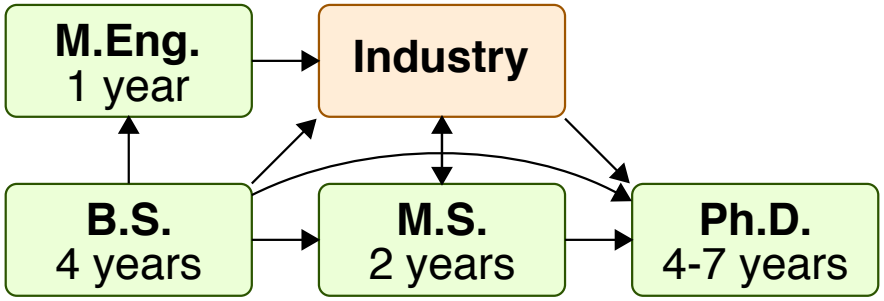
When to pursue a Ph.D. in engineering?

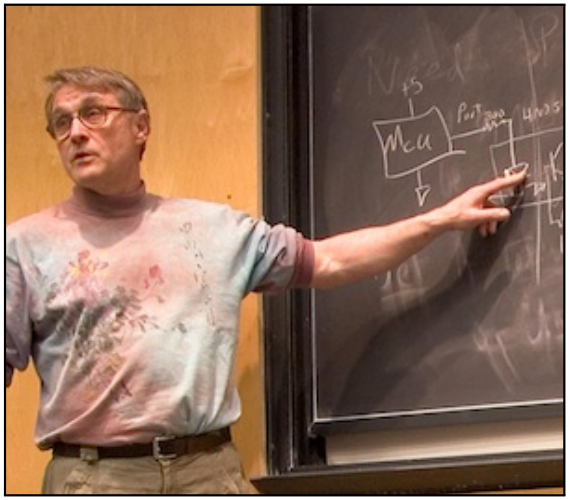


- Most students enter a Ph.D. program right after finishing a B.S.
  - Some Ph.D. programs include the option/requirement to earn an M.S.
- Some students pursue an M.S. first and then enter a Ph.D. program
  - Some M.S. programs designed as terminal degrees
  - Some M.S. programs designed as step towards Ph.D. at same institution
  - Some M.S. programs designed as step towards Ph.D. at any institution
- Certainly possible to go into industry and return for an M.S. or Ph.D.
  - Part-time M.S. programs are popular for those working full-time
  - Longer one is in industry, less likely to return for a Ph.D.

Why pursue a Ph.D. in engineering?

- Opens up new career opportunities that can enable you to fundamentally shape the future of our society from ...
  - ... *academia* through teaching and research
  - ... *industry* through research and development
  - ... *government* through research, application, and policy

Academia



Prof. Bruce Land at Cornell

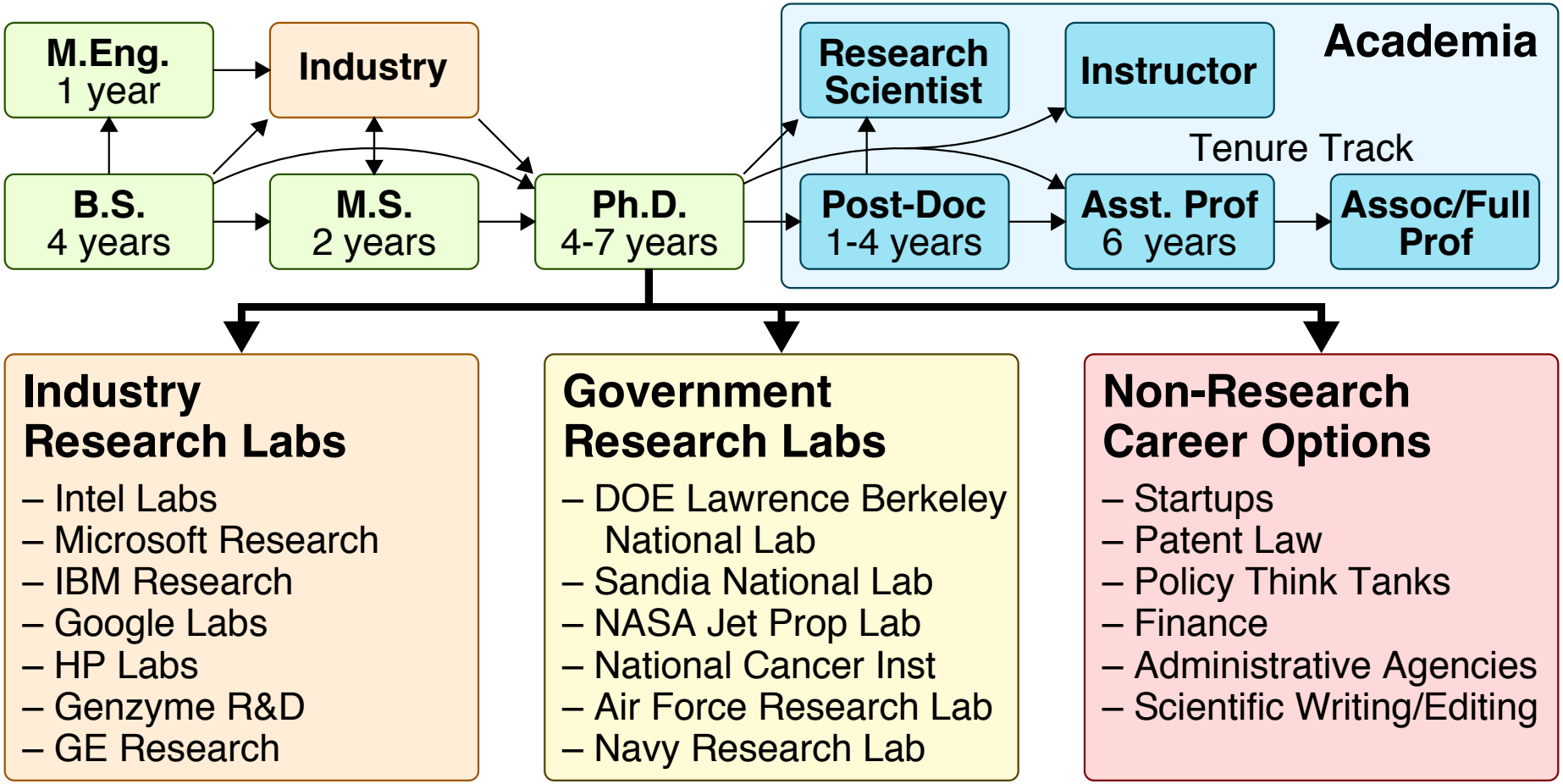
Industry

Silicon Photonic Interconnect at Intel Labs

Government

Titan Supercomputer at Oak Ridge National Lab

Why pursue a Ph.D. in engineering?



A doctoral degree demonstrates that you have a deep understanding and expertise in a specific area, but also can creatively invent new ideas and analyze, demonstrate, and evaluate these ideas in practice

What is earning a Ph.D. in engineering like?

	Undergraduate	Graduate
Focus	acquiring broad foundational knowledge through coursework	acquiring deep expertise on a single topic through research
Schedule	externally driven by lectures, discussion sections, problem sets, exams, study groups	independently driven by planning, running, analyzing experiments, meeting with colleagues, writing papers, attending conferences
Funding	responsibility of student	fellowship, teaching assistantship, research assistantship ($\approx$\$30K/year)
Breaks	relax at home or summer internship	stay and work on research or summer internship

What is earning a Ph.D. in engineering like?

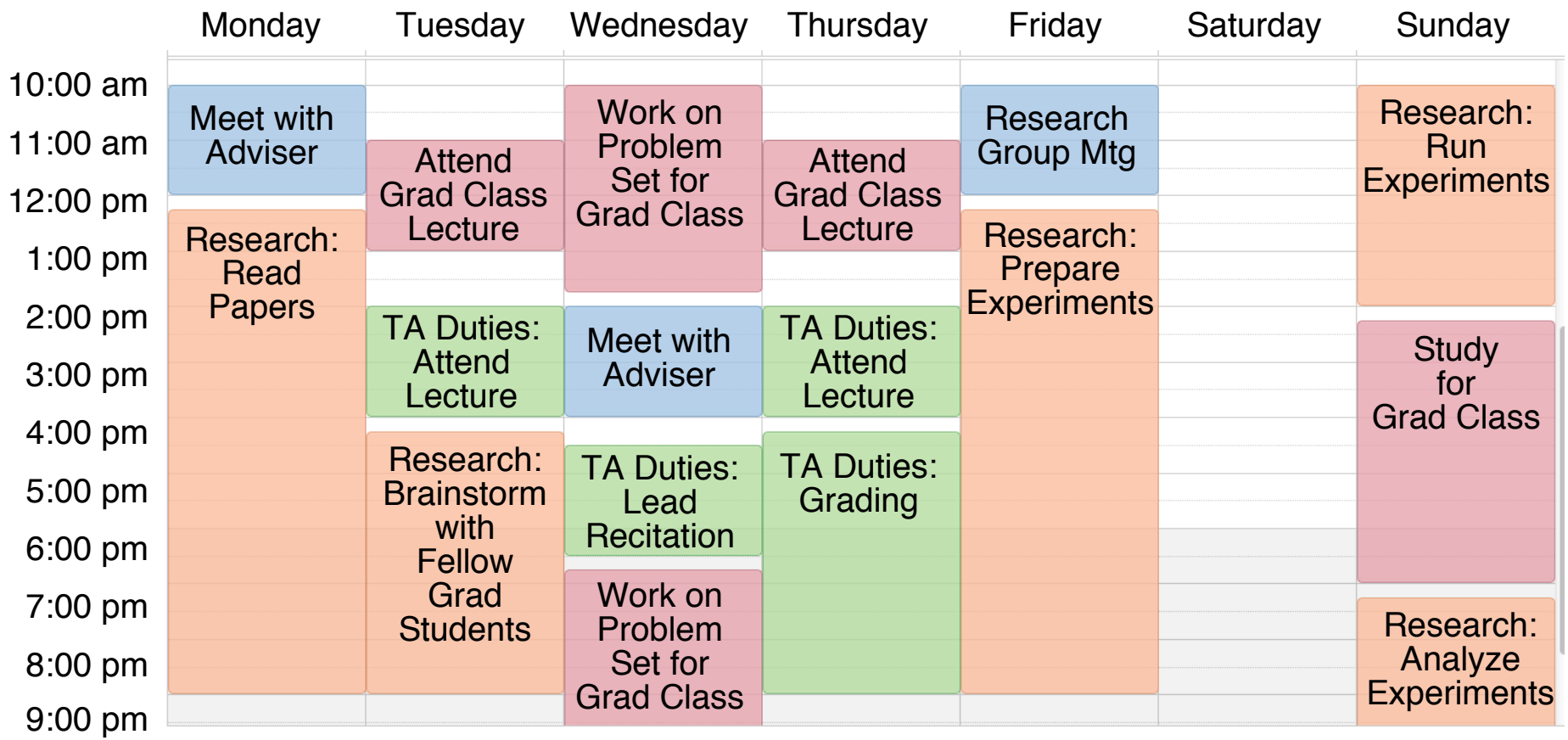
Earning a Ph.D. is *not* an "advanced" version of your undergraduate education

Earning a Ph.D. is more of a flexible job for relatively little pay but with tremendous opportunities

Earning a Ph.D. is probably not the best way to "learn more" about a field that interests you

Earning a Ph.D. = Research

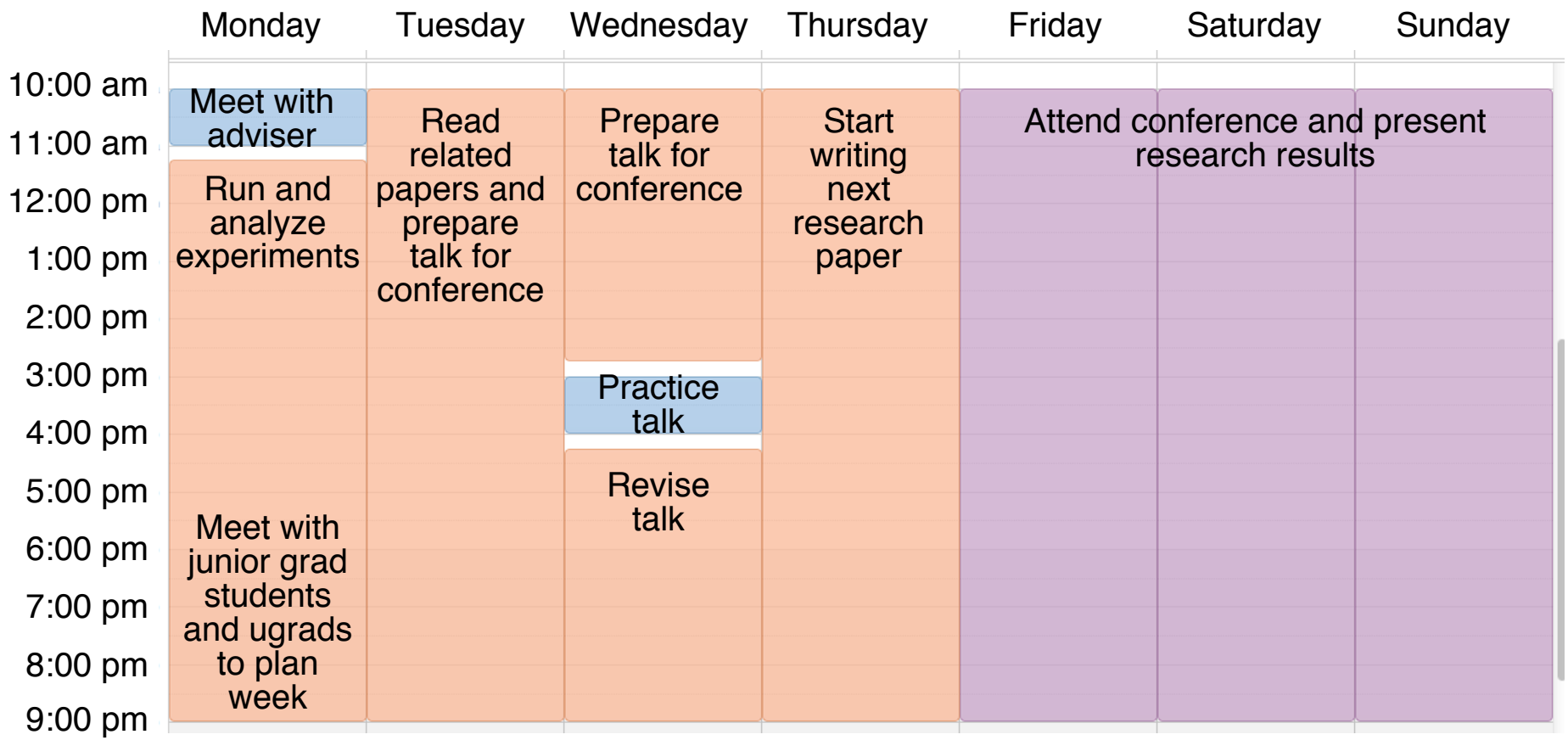
Week in the Life of a Junior Graduate Student



First years involve a mix of research, teaching, and taking classes

Includes close interaction with faculty research adviser

Week in the Life of a Senior Graduate Student



Final years focus mostly on conducting, writing, and presenting research

More independence from faculty research adviser

Where to pursue your Ph.D. in engineering?

- Top graduate schools in computer architecture (no particular order)
  - Massachusetts Institute of Technology
  - Stanford University
  - University of California, Berkeley
  - Carnegie Mellon University
  - University of Illinois, Urbana Champaign
  - Cornell University
  - Georgia Institute of Technology
  - University of Michigan, Ann Arbor
  - University of Texas, Austin
  - Princeton University
  - University of Wisconsin, Madison
  - University Washington
  - University of California, San Diego
  - others ...

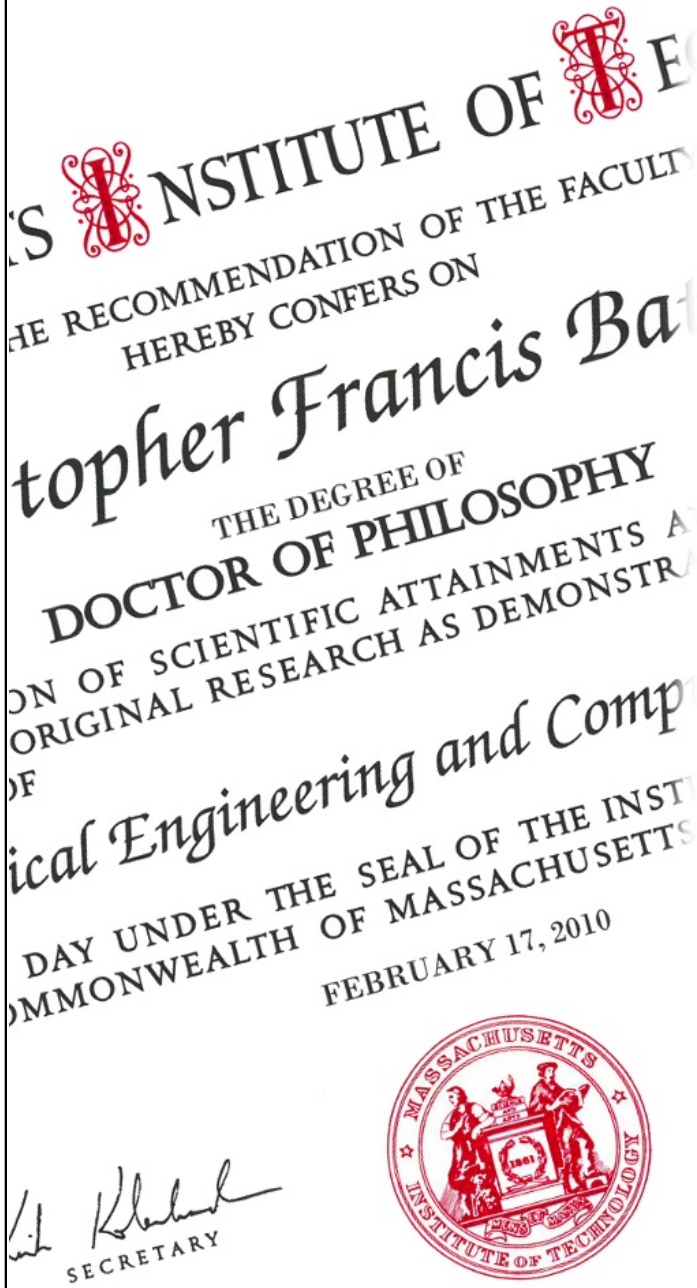
Many schools you might not think of can be very strong in specific fields; cast a wide net across all tiers

Strongly recommend *not* pursuing your Ph.D. at your undergraduate institution

Who should pursue a Ph.D. in engineering?

Intelligent, self-motivated, hard-working, and creative students who love learning, exploring, and inventing and ultimately want to fundamentally shape the future of our society

- Myths about pursuing a Ph.D.: I can only pursue a Ph.D. if ...
  - ... I have a 4.0 GPA
  - ... I want to become a professor
  - ... I already have tons of research experience
  - ... I already know my exact research topic
- Best way to learn if a Ph.D. is right for you is to ...
  - ... talk to your professors
  - ... talk to current graduate students at Cornell
  - ... talk to your friends who are already in graduate programs



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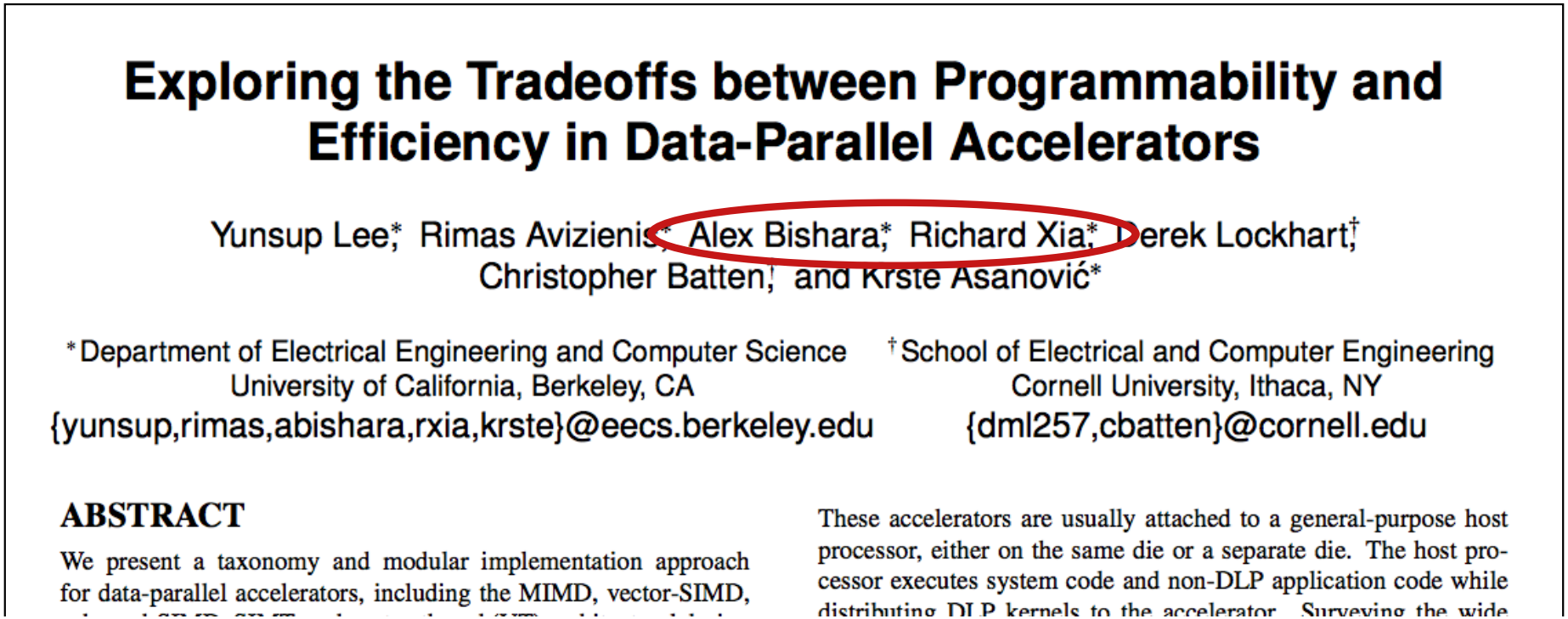
How to Succeed as an Undergraduate Researcher

- Goal: Learn what research is like, how to be effective researcher
  - Work hard on a focused, independent research project
  - Keep a detailed lab notebook
  - Read and discuss research papers, learn broadly about the field
  - Form relationships with graduate students in the research group
  - Attend research group meetings
  - Attend research talks by internal and external speakers
- Goal: Establish a relationship with a faculty in preparation for the faculty to write a strong letter advocating on your behalf
  - “best student I have seen in X years”
  - “able to read, synthesize, and report on research papers in the field”
  - “creative, came up with interesting new insights or ideas”
  - “self-motivated and hard-working, got things done”
  - “valuable team member, productively contributed to larger research group”

How to Succeed as an Undergraduate Researcher

- Non-Goal: Do amazing research resulting in many publications
  - Usually not practical for an undergraduate to drive a research project
  - Contributing to a publication is of course great
  - Often undergraduate research projects are “off the critical path”



Exploring the Tradeoffs between Programmability and Efficiency in Data-Parallel Accelerators

Yunsup Lee[*], Rimas Avizienis[*], Alex Bishara[*], Richard Xia[*], Derek Lockhart[†], Christopher Batten[†], and Krste Asanović[*]

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ABSTRACT

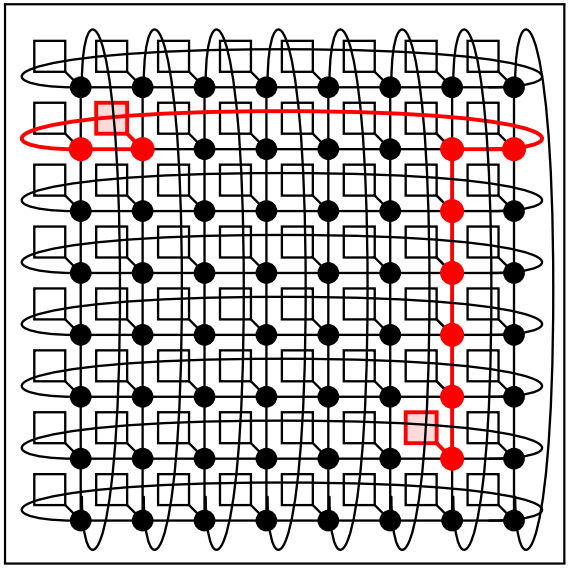
We present a taxonomy and modular implementation approach for data-parallel accelerators, including the MIMD, vector-SIMD,

These accelerators are usually attached to a general-purpose host processor, either on the same die or a separate die. The host processor executes system code and non-DLP application code while distributing DLP kernels to the accelerator. Surveying the wide

Undergraduate Researchers in My Lab

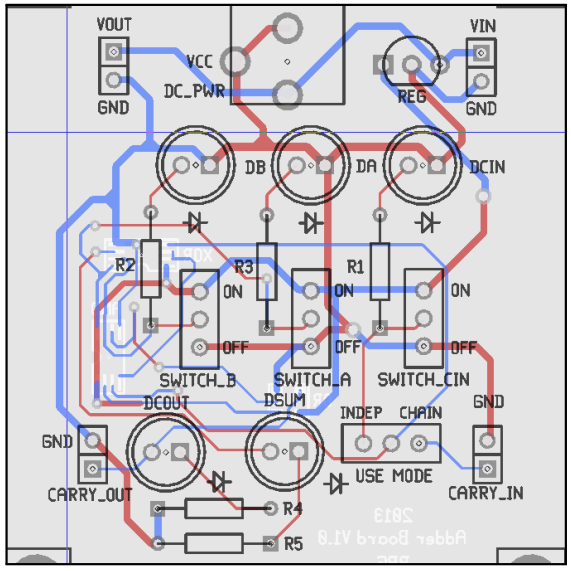
Undergraduate researchers in my group often work their way up from implementing infrastructure, to evaluating design alternatives, to creating their own designs

Matt Ogleari, BS'13



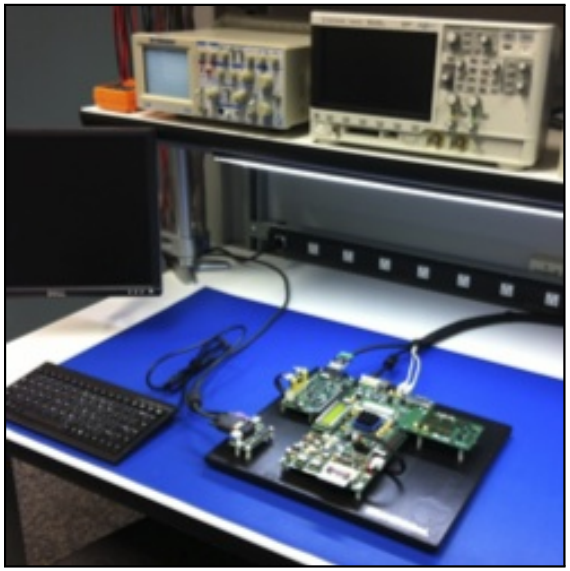
Exploring on-chip interconnection networks through simulation

Alvin Wijaya, BS'15



Building circuit boards for prototyping, exploring multicore prototype

Jonya Chen, BS'16



Exploring hardware prototype of simple sorting accelerator

How to Succeed in Applying to Graduate School

General Process

- Application deadlines are usually between early Dec to early Jan
- Possible phone interview in early spring
- Notification of acceptance on a rolling basis throughout the spring
- Specific faculty may contact you expressing interest
- Prospective graduate student visit day
- Decisions required by April 15th

Application Materials

- Transcripts, GPA, GREs
- Statement of Purpose ($\approx$2 pages)
- Letters of Recommendation (usually three letters)
- Resume

Graduate student applications are read, discussed, and judged by faculty, not by an office of administrators!

Graduate Application: Statement of Purpose

- Focus less on why graduate school would be great for you as a person and more on why you will be an awesome graduate student able to do amazing research
- Try to provide evidence for why you will be an awesome graduate student by illustrating your intelligence, self motivation, work ethic, and creativity through appropriate foundational coursework, course design projects, internships, and research experiences
- Use a structured approach: first paragraph provides overview of background and highlights general area you are interested in exploring (*who should read the app?*), divide statement into sections to highlight different experiences and future interests
- Establish a compelling theme which begins in your statement of purpose and ties together your transcript, letters, and resume

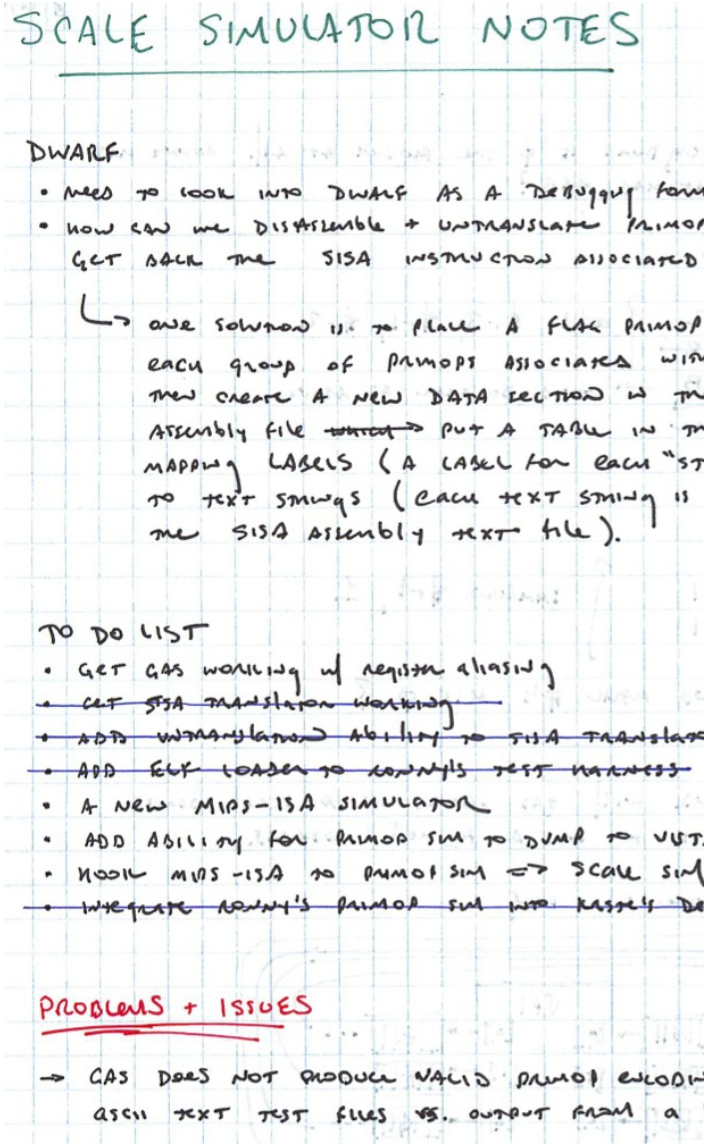
(Example Statement of Purpose)

Graduate Application: Letters of Recommendation

- Tremendously important, basically a faculty is vouching for your potential to their colleagues – and they have to live with their recommendation for the duration of your graduate career!
- Start thinking as soon as possible about which faculty to ask, prefer faculty who know you very well and can speak in detail about why you will be an amazing graduate student (ideally more than just an instructor in a large course)
- Internship supervisors, academic advisers, post-docs are okay, but often the difference between accept/reject is based on the letter from the faculty who has worked closely with you on a project
- Prepare your letter writers by providing your transcript, statement, resume; a description of your theme; list of what you would like he or she to highlight; list of schools and deadlines

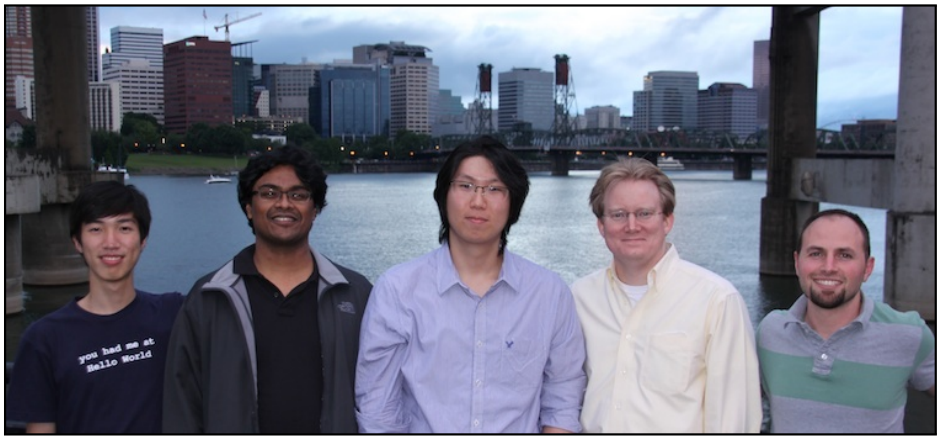
How to Succeed as a Graduate Student

- Keep detailed notes on every idea, meeting, paper, conference
- Create a schedule, ensure most difficult work is when you are most productive
- Make time every week to read old/new research papers in your field, but don't get easily discouraged by papers which seem to have already solved the problem
- Experiment with ways to stay productive
- Balance "getting it done now" with "getting it done right"
- Fail early & often; Invest a little, learn a lot



How to Succeed as a Graduate Student

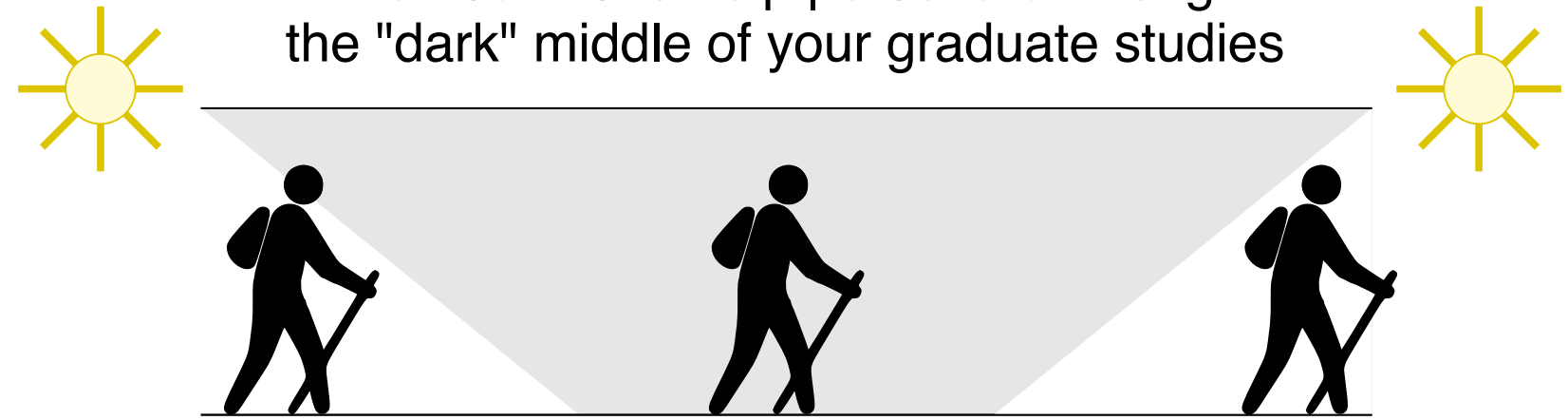
- Build your professional network
  - Try to attend conferences where you are not presenting, offer to pay housing/food if adviser pays travel/registration
  - Talk to as many people as you can, push yourself out of your comfort zone



Int'l Symp. on Computer Architecture
Portland, OR, June 2012

  - Take advantage of off-line post-presentation discussion with presenting students at conferences, opens opportunities for discussion with faculty
  - More senior graduate students should consider giving "invited" talks at other universities

Remember the passion which drove you to pursue a PhD
and use this to help persevere through
the "dark" middle of your graduate studies



Beginning of PhD Middle of PhD End of PhD

Jorge Cham © 2009

Take-Away Points

When? After your B.S., after an M.S., or after a short time in industry

Why? Open up new career opportunities that can enable you to fundamentally shape the future of our society

What? Graduate school is very different from your undergraduate experience with a focus on acquiring deep expertise on a single topic through years of research

Where? Many options at all tiers, both expected and unexpected

Who? Intelligent, self-motivated, hard-working, and creative students who love learning, exploring, and inventing

How? Get involved in undergraduate research, form a compelling theme for your application, and persevere through graduate school while building your professional network

This is just my opinion.

Synthesize many opinions to form your own roadmap!