

CSE 101, Winter 2011

Design and Analysis of Algorithms

Lecture 18: Research and Graduate School ++

(edited for posting)

Topics for Today

- **Context**
- **Research**
- **Graduate School**
- **Life and Career Skills**

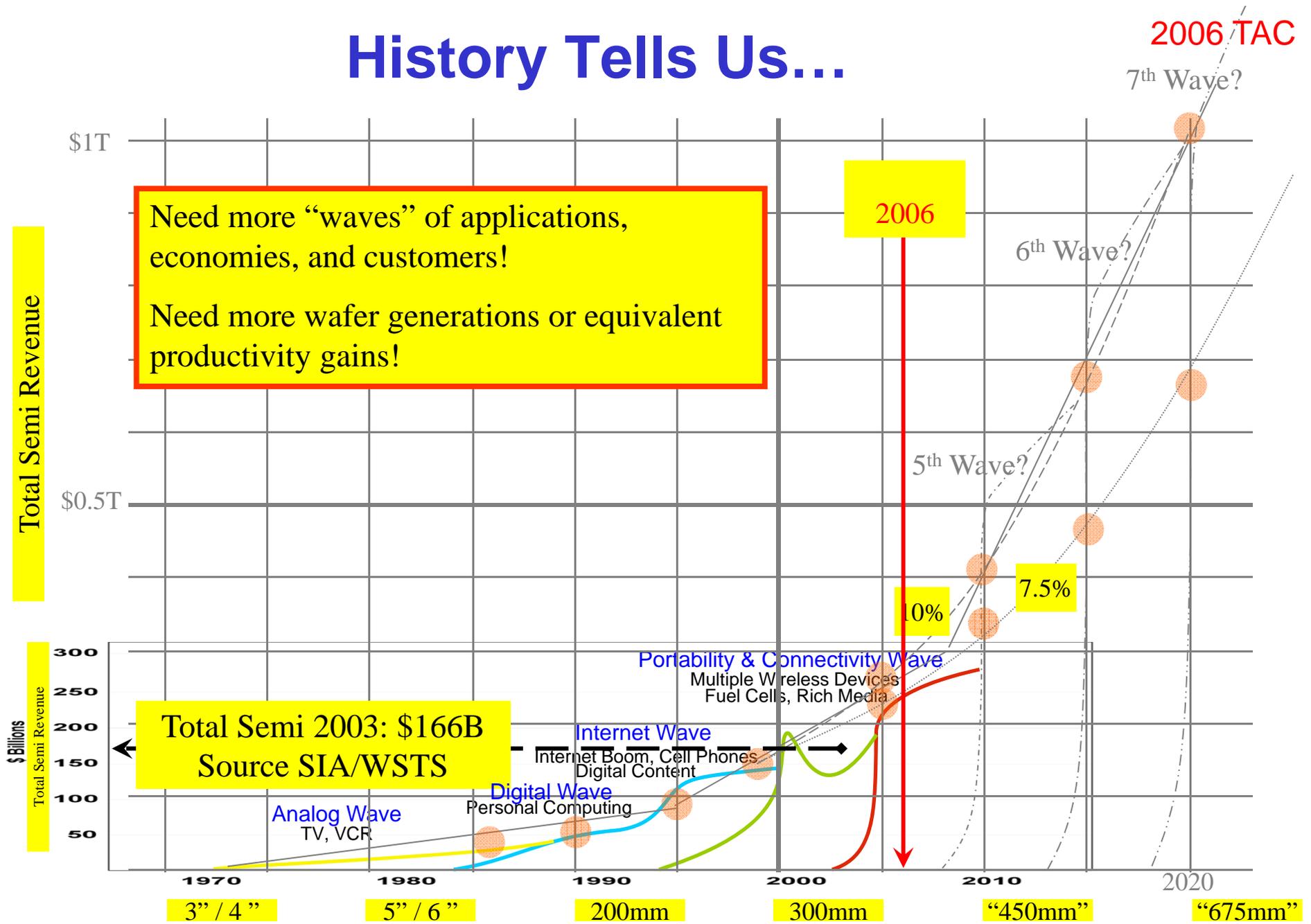
Why You Should Listen To Me 😊

- <http://vlsicad.ucsd.edu/~abk/biodata.html>
- **Seriously**
 - **I train my students to be successful**
 - Ph.D. graduates now professors at Michigan, UCLA, Virginia, Brown, ...
 - Other graduates are successful entrepreneurs (software/systems) and R&D leaders
 - **Have served on technology advisory boards/councils of many technology companies across several industries (software, systems, semiconductors, semiconductor supply chain)**
 - **Have gained perspective from experiences in industry, startup, academic research, academic administration, consortia, technology roadmapping, ...**

ON CONTEXT

Beginning in 2005, I served on Samsung Electronics Corp.'s "Technology Advisory Council" (~8 professors from around the world). The "TAC Forum" each year included a panel discussion to address various questions of current interest to the company. The following "context" slides are excerpted from a few of my panel presentations over the years. They are "semiconductor-centric", but convey the point of looking at the big picture.

History Tells Us...

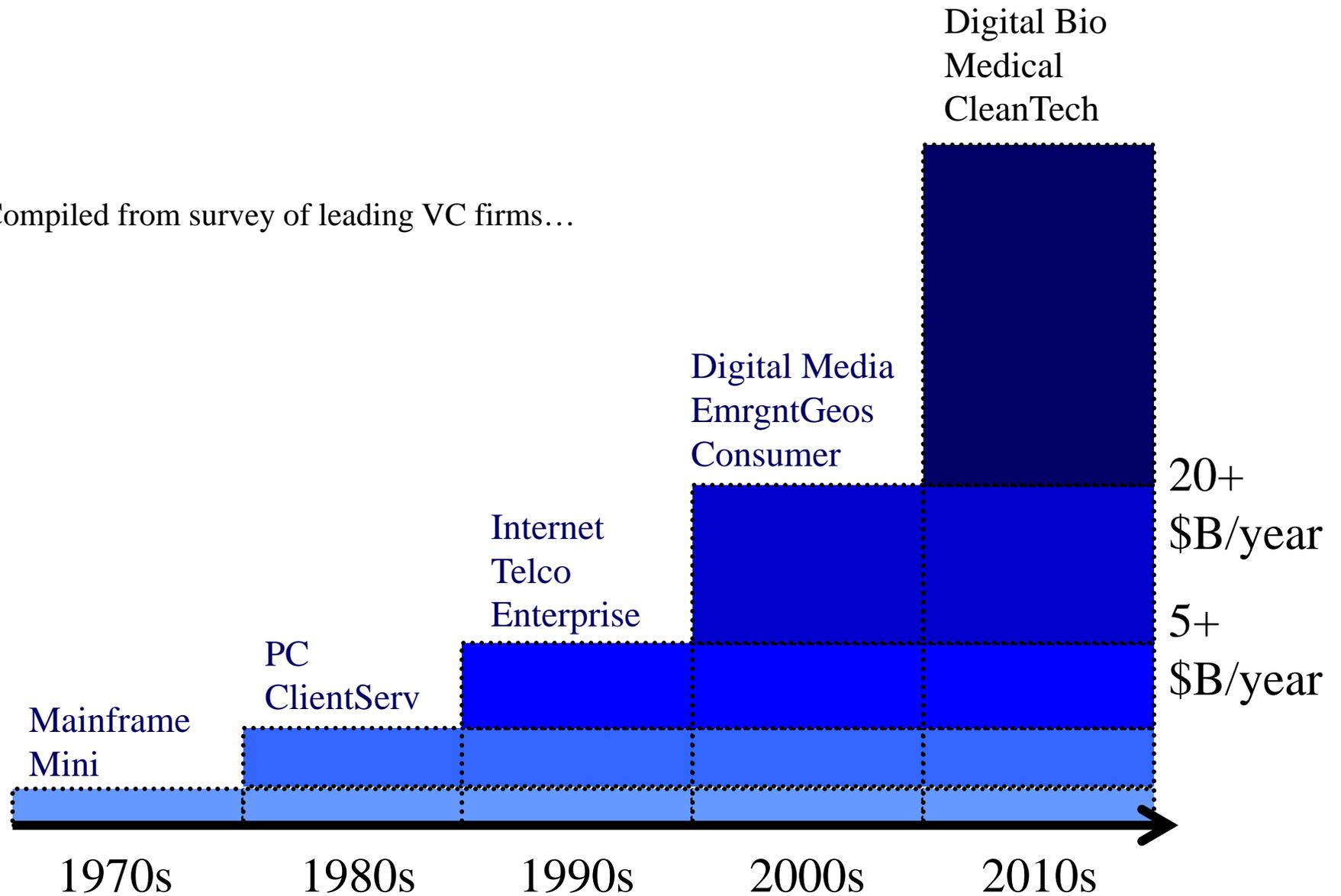


Source: Semico Research Corp, May'04

Source: ITRS ORTCs / Alan Allan, Sept. 2005

Technology Waves and VC Investment 2006 TAC

Compiled from survey of leading VC firms...



Source: ITRS Design ITWG, April 2006

1. What Applications Will Lead ?

- Communication and signal-processing applications continue to displace computing applications in defining “paradigmatic ICs”
- Bioelectronics becomes a key application area
 - I.e., all types of applications of integrated electronics to the biomedical area
 - Implantable diagnostic devices
 - Integrated bio-sensors for DNA/protein discovery
 - Cheap medical test instruments
- Leisure
 - Games, entertainment, multimedia, ...
- Automotive, industrial electronics, military, security

2. What Technologies Will Be Required?

- **Greater levels of integration**
 - Packaging, random-logic and memory, digital and analog, passive and active, electrical and mechanical (including microfluidics), etc. in 3D
- **Bio-electronics applications**
 - Micro-fluidics
 - Discovering chemical / biological tests that permit detection of reactions by means of optical emission, or thermal or electrical changes in the reagents, in ways that are implementable on chip
 - Issues of cost, integration, and reliability must be understood
- **General electronics**
 - Require success of very high density self-aligning technologies (nanotubes, molecular transistors)
 - → 3 orders of magnitude density increase, less switching energy compared with end-of-scaling CMOS
 - Must comprehend optimal architectures and even algorithms that exploit very high density of emerging technologies

Sense x Simplicity = Utility

- Claassen's Logarithmic Law of Usefulness
- **Sense** = What humans need from silicon
 - B/W TV → Color TV → HD TV → ... → ?
 - NAND Flash with MLC (or, PCM)
 - >> 400GB/cm² by 2020
 - 40TB = 80 years of continuous music
 - Mobile micro-HD
 - E.g., probe storage >> Tb/in²
 - 792 feet of books = 7 million pages = 25GB
 - 90TB = all 530 miles of bookshelves in Library of Congress
 - Life recorders? VR / telepresence? ... Teleportation?
- **Simplicity** = What humans can use
 - *"I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I no longer know how to use my telephone."* -- B. Stroustrup

4. For Students and Engineers?

• Students: De-specialize !

- Be creative and aware
- Learn physics, chemistry or biology
- Learn how to program parallel and heterogeneous systems
- Understand the context for what you do, and why you do it

• Engineers: Engage !

- Attend conferences, read, publish
- Formulate what you want researchers to deliver
- Engage with university community

• VPs and CTOs: Differentiate !

- People, tools, processes, cultures, IP
- Don't be shy with external research \$
 - Finger on the pulse of innovation and IP
 - Cheap lock-outs / exclusivity of access

		Differentiating Value Added	
		Low	High
Permanence	Easily Lost	Processes	People
	Easily Kept	X	Tools, IP Cultures

How Will Technology Evolve?

- **Continued Moore's Law scaling of integration, value**
 - Three fundamentals: memory, interconnect, 3D
 - Scaling to **< 20nm** based on photolithography **is unclear**
 - Equivalent scaling from software, stacking, architecture, ...
- **Trajectories**
 - *Applications* still driven by mobility, bio, clean tech, leisure
 - Portable multimedia, graphics resolution, core network bandwidth
 - **Photovoltaics !!!**
 - *Massive storage* driven by Flash (e.g., TB in cell phone)
 - *Human-machine interaction*: Intelligent, cognitive, natural
 - Augment reality with a virtual world
 - *Power and energy*: harvesting, management, portability
 - *Closing the committed vs. programmable ("FPGA-ASIC") gap* via architectural organization of processing, memory, communication blocks
 - **From last year:** *Circuits* (subthreshold; multi-radio smarts and interfaces) *and systems* (spatially-adaptive, ultra low duty-cycled); *Processing* (driven by parallelizable applications)

Changes to the Semiconductor Industry

- **Bifurcation between developed world and emerging countries**
 - Deepening bifurcation between high-end and low-end semiconductor industries
 - Emerging regions will be increasingly important
 - New global players continue to come from emerging countries → acquire developed-country players
- **More Than Moore**
 - Growing part of product value comes from highly complex software and non-digital/CMOS (analog, MEMS)
 - Must be a major focus for innovation
- **Structural changes due to PV, memory**
 - PV (CZ/FZ/polycrystalline) impact on Si supply chain
 - Imaging / image sensing, mass storage, NV affect memory
- **Emergence of an applications long tail?**
 - Heterogeneous multi-core with programmable fabrics → opens door to the long tail of embedded applications

Directions To Take To ~~Be Competitive~~ Win

- **Must be able to deliver SW/HW solutions**
 - Limiting case in 2020: HW is free, consumers buy services
 - Design technology is critical
 - Who will be first to enable parallel SW development?
 - Who will leverage DFM to regain cost trajectory of manufacturing?
- **Global collaboration is key**
 - Sharing of IP, NRE, fab cost, royalties; JV participation
 - Don't be isolated
- **Must have big footprint in emerging economies**
 - Aggressive collaboration and partnership policy, strategy
 - Acquire aggressively to spur growth and innovation that cannot happen enough internally
- **Shift the cost crossover point for low-volume product**
 - Else, IC sockets go unused or filled by expensive silicon
- **Keep an eye on:**
 - Obvious: IP, new memory technologies, ...
 - Energy application space
 - Massive energy capture or dissipation through semiconductors (solar capture, wind capture, thin layers that isolate layers of clothes)
 - Online energy regulation, downstream effects of PV, ...

TAKEAWAYS

- **Think Big Picture**

- **Richard Hamming, “You and Your Research”**

- Each week from Friday noon onward, only think about “big problems”
- <http://vlscad.ucsd.edu/Research/Advice/hamming.html>
- <http://vlscad.ucsd.edu/Research/Advice/index.html> ← check this out (Pausch on time management, Raibert on good writing, ...)

- **Steve Teig**

- In 2002, broke Edison’s record for number of patents filed in a single year by an individual
- 1997 conversation about “things to work on”: [turn cellulose into gasoline, recover gold from seawater, ...](#)

- **Build transferable skills**

- **You will still be working 50 years from now. What skills should you learn today?**
- **Toolkits:** global optimization; machine learning; concurrency; systems design; modeling and simulation; ...
- **Skills for the engineering life:** how to study for a lifetime; how to be flexible; how to stay curious, inventive and motivated; ...

ON RESEARCH

What is Research?

- **Research = Discovery at the Leading Edge**
- Many varieties
 - Basic vs. Applied
 - Theoretical vs. Experimental
 - Hardware vs. Software
 - Lab vs. Simulation
 - High-Risk-High-Return vs. “Turning the Crank”
 - Fashionable vs. Unfashionable
 - (Some of the above may not be research in the complete sense – e.g., if you know the result in advance, is it “research”...?)
- Key aspects that make research difficult
 - **Discovery** – by definition, of what is previously unknown
 - **Leading Edge** – implicitly, must comprehend the leading edge

Research (Ideally) is Life Training

- Life = one big optimization ?
= one big problem to solve ?
- Research will grow you
 - Go where no one has gone before → ego, autonomy, challenge
 - Stamina and perseverance → Polya's mouse, hard work pays off, etc.
 - “Seeking truth”: relatively honest, w/ ignorable politics, value judgements
 - Fundamental optimism (!)
- Research process and life cycle impart very, very good training*
 - Read and understand relevant literature, motivating application context
 - Synthesize, establish formalisms
 - Formulate a problem
 - Conceive a solution
 - Design an experiment
 - Implement and validate
 - Communicate results – orally and in writing, to general/expert audiences

* There are many roles in the research process: manager, idea generator, coder, bottle-washer, ... The above life cycle spans [idea generator, ..., coder]; management is a whole other aspect. Don't be a bottle-washer and think that you've gained “research experience”. It is very important to attempt the entire research life cycle!!!

TAKEAWAYS

- **Research can drive a way of thinking and living !**
 - Inspirations: Feynman, von Neumann, Knuth, ...
- **It forces development of a surprisingly broad array of skills that can serve you well in life !**
 - Abstraction
 - Problem-solving
 - Independent thinking
 - Communication
- **It is not for everyone**
 - Too unstructured ☹
- **“Bad research” has extreme negative value ☹ ☹ ☹**
 - Unscholarly behaviors = ignoring or avoiding previous work, non-probative experiments, absence of scientific method, addressing meaningless problems, cluttering research landscape, ... → bad for you as a person, IMO

ON GRADUATE SCHOOL

I served as graduate vice-chair of the UCLA CS department from 1998-2000, and at UCSD CSE have been associate chair in 2003-2004 and chair of the graduate committee in 2008-2009. I've also served on various admissions, fellowship, scholarship etc. committees over the years.

Why Graduate School?

- Learn more!
- Try the research life
 - Cool stuff, fun, challenging, ...
- Future economic benefit
 - Improve market value while stuck in a down economy
 - Check <http://www.cra.org/govaffairs/blog/wp-content/uploads/2010/03/CRATaulbee-2010-ComputingDegreeandEnrollmentTrends.pdf> vs. unemployment rate
 - [Several studies of net present value: economic benefits may be illusory]
- Path to entrepreneurial career
 - Smart people, great networking, easy to escape with IP
- Want to be a teacher or researcher
 - Need advanced degree
- Other
 - Parents, culture, path of least resistance, ...

Basic Paths

- When
 - Straight from undergrad
 - After working for a few years
 - While working
 - Companies often reimburse all expenses of part-time (M.S.) students
 - Some Ph.D. programs discourage part-time students
- What degree, and to what end
 - M.S.
 - Terminal, to gain advanced knowledge (note: not “skills” per se!)
 - E.g., M.S. courses won’t make you a strong coder, scripter, writer, ...
 - Terminal, but back door to Ph.D.
 - Couldn’t get in to Ph.D. program, hope to impress
 - Warning: some schools still explicitly prevent back doors into Ph.D. program
 - To “try out” research before going for a Ph.D.
 - E.g., choose the “M.S. Thesis” option instead of the “M.S. by courses only” option
 - Warning: many research advisors don’t invest in learning curve of an M.S. student (i.e., less chances of pay)
 - Ph.D.
 - Faculty – research school
 - Faculty – teaching school
 - Researcher
- With support (fellowship, RA, TA) or paying your own way

Random M.S. vs. Ph.D. Comments

- **M.S.**

- Mostly courses; less opportunity for research
- Often, second-class citizen (M.S. programs are increasingly evolving into hoped-for profit centers – certificates, professional master's, ...)
- Faculty don't want to invest too much in you if you'll be gone in < 2 years
 - Each of my Ph.D. students costs \$70K in contract/grant funds per year (> 1/3 is “overhead”)

- **Ph.D.**

- My exit criterion #1: You are the world's expert on your thesis topic at the moment you graduate
- My exit criterion #2: You have command of all aspects of the research life cycle, and relevant skill sets
- **Most common pitfall: Too much time on courses in first 1-2 years, find out that you don't like / aren't good at research only after this**
- Another pitfall: Too much time spent supporting yourself with TA-ships, internships, etc. (You're staying in school to do research, not grade HW)
 - Note: Many Ph.D. programs have a teaching practicum requirement, which is fine. **The point is to not be forced to detract from your research aims by an advisor who can't support you...**
- Your mileage will vary greatly with advisor
 - “How to Be a Good Graduate Student”: <http://vlsicad.ucsd.edu/Research/Advice/how.2b.html>

Going To Graduate School (Ph.D.)

- **Go to the best place you can**
 - Of course, should be strong in your area of interest (CHI, graphics, algorithms, robotics, ...)
 - If you have no area of interest, you may wish to pursue an M.S. first...
 - Students and student quality are ultimately what make a program great
- **Understand the competitive threshold**
 - Good (or, strong and clear improvement) grades; good GREs
 - Three (3) letters from faculty or researchers
 - Assistant professor vs. full professor: senior faculty can say “best in 20 years” etc. (+ other factors)
 - Lock these down early, before they forget your name and face ☹
 - “Summer job supervisor” or even “internship supervisor”: less weight
 - Letters from “lecturer” or “visiting faculty”, and/or pertaining to lower-division courses: less weight
 - “Character reference” (pastor, English professor, etc.): likely very little weight
 - Research experience (ideally, a published paper)
- **Timing: work backward from application date** *begin with the end in mind*
 - Apply for Fall of Year N admission in December of Year N – 1
 - Complete research experience by June of Year N – 1 at very latest
 - Quarter+ in a lab? Paper submission? Internship?

Approaching a Professor (for Research)

- **Do your homework**
 - FAIL example:
 - Student: “Hi, I’m thinking of graduate school and I’d really like to do a research project in your lab.”
 - Professor: “Sure, that sounds good. On what topic?”
 - Student: “Um, well, what are your research topics?”
 - Read webpage and some papers
 - Treat this at least as seriously as a screening interview
- **Talk to the professor’s graduate students**
 - Is the group well-reputed and successful?
 - Can students suggest opportunities to “help out”? (Coding, running experiments, ...)
 - Is there a weekly lab/group research meeting that you can attend?
 - What is the culture of the group? Hard-working? Fun? (Ideally, both.)
- **Think through what you want, and what you can offer**
 - You want: Clearly defined project; outcome of [research paper submitted for publication] in a time frame of [5 months]; grad school letter of recommendation; ...
 - You offer: What are you good at? How many quality hours (% mindshare) will you absolutely deliver each week?
 - And, you won’t be a huge time sink...

Approaching a Professor (for Research)

- **Then, ask for an appointment**
 - Bring a resume
 - Bring a transcript
 - Be knowledgeable about what the lab does
 - Be ready to say what you are interested in
 - Be ready to close the deal
 - Be ready to start with your hair on fire

Grad School Application Process

- **[real-time browsing example?] Message: it's competitive!**
 - Leverage your advantages state resident (there are quotas!), demographic, native English skills → good TA material, etc.
- **At UCSD, work (with) your letter-writers**
 - “Would you be willing to write me a strong letter of recommendation that will allow me to be competitive at UT Austin?”
 - “strong” is an academic keyword. There are many, many gradations in “letter-speak”.
 - “Joe has my {highest, strongest} {possible} recommendation”; “I {highly, strongly} recommend Joe”; “I {warmly} recommend Joe”; ...
 - Tell them talking points they should make (better than for you to make)
 - “Joe had mono in junior year, so his grades that year are an anomaly”
 - “Joe spends 20 hours a week building PCs and teaching Java to disadvantaged youths”
 - Have them (and other mentors) contact faculty at your target program
 - “I’d like to bring to your attention one of our best undergraduates, Joe, who has applied...”
- **Make sure your application is complete by the deadline!**
- **Contact professors at your target program**
 - They will hopefully keep an eye out for your file
- **Keep your target program updated on any news**
 - Paper accepted in ACM Conf. on XYZ
 - Straight A’s last quarter
 - Just got accepted to MIT’s Ph.D. program but still really hoping to enroll at your school next fall ... **“no one helps a drowning man”**

TAKEAWAYS

- **It's competitive**
 - Students from India, China, Iran, Korea, ... still want to come to U.S. for Ph.D. study
 - Typical top-10 program: 1000+ Ph.D. applicants, entering class ~size of the faculty
 - But you have many advantages (English skills, U.S. residence, sitting at a strong research university, ...)!
- **Start your campaign now**
 - Make whatever moves you can to keep options open and maximize future chances
 - Lock in letters from your past “A” classes
 - Budget time to get research experience and a strong letter-writer
 - The research process cannot be compressed: you must start earlier rather than later
 - You have more levers than you think!
 - Working (with) letter-writers, etc.
- **Go to the strongest program that you can**

ON LIFE AND CAREER SKILLS

From October 2004 to September 2006, I served as co-founder, chairman and CTO of a Sunnyvale-based software startup that commercialized a UCSD invention, now available as a “green technology” from TSMC – see http://www.tsmc.com/english/csr/design_for_low_power_consumption_and_green_products.htm

I compiled a CSE 91 talk based on some lessons learned. Following are some excerpts – management- and startup-centric, but generally useful.

MANAGEMENT (including self-management)

Leadership:	knowing what to do
Management:	knowing how to do it
Vision:	lofty goal to achieve
Mission:	how you are going to achieve it

*Covey's Seven Habits

CSE91
Fall 2008



*Quadrant 2

CSE91
Fall 2008

	Urgent	Not Urgent
Important	Q1 Deadlines Customer Problems Certain Meetings Unexpected crisis	Q2 Roadmap development Improve Processes Build infrastructure Social Events, Mentoring Improve Communication
Not Important	Q3 Some meetings, some phone calls, some errands	Q4 Goofing off Web surfing Gossiping

*Management Advice

- Experience various job functions
 - R&D, marketing, customer support, QA, sales
- Learn and practice management skills
 - 7 habits, personality, decision making, financial analysis, legal, ...
 - Understand the importance of reviews
 - Hierarchy of importance → everyone knows this, all the time
- Act and analyze in the company interest
 - Including unpopular conclusions
- Learn the customer's perspective
 - Make the customer talk
- Learn cultural issues
- Lack of success is a training experience
 - “Good decisions come from experience. Experience comes from bad decisions.”*
- Act!

Understanding of this advice comes with experience!

What To Spend Time On

- **Planning**
 - “Failing to plan is planning to fail”
 - stitch in time, ounce of prevention, ...
 - Basic error: the “inverted pyramid”
 - Decide to do something (1 day), make a plan (1 week), develop per plan (1 year...)
 - Plans should never be set in stone: must revisit them and adapt continuously
 - Financials, product engineering, go-to-market, growth
- **Homework**
 - Market, competitive landscape, financials/legal, roadmap, ...
 - Be prepared (for meetings, presentations, ...) → backups + backstops
- **Processes**
 - Software development (e.g., extreme programming, code review, ...)
 - Repeatable customer engagement and sales process
 - IP documentation and protection
- **Metrics**
 - You must measure to improve

These are essential elements of a strong culture

*Easier To Say Than Do

- Know your strengths and weaknesses
 - Hire to address weaknesses
 - Create mix of personality and perspective on team
- Your manager's and your team's success are your successes
- Fix problems ASAP
 - Attitude and teamwork are big problems
- Learn to identify and recruit A players with usable talents
 - *(What is the difference between a skill and a talent?)*
- Work very hard
- Learn from your experiences

TAKEAWAYS

- **Think about your goals**
 - Work backward from them
 - Do your homework (and then trust your instincts)
 - Have a plan
- **Work hard**
 - Moore's Law: 1% per week
- **Measure to Improve**
 - Benchmarking
- **Enjoy what you do**
 - My Ph.D. advisor: “Always do what you would do if you were stranded on a desert island”
 - Shane Robison (HP CTO): “Are you having fun?”
 - [Tiger mom: Success makes it fun 😊]