

Why Computer Science? Why UW CSE?

Ed Lazowska

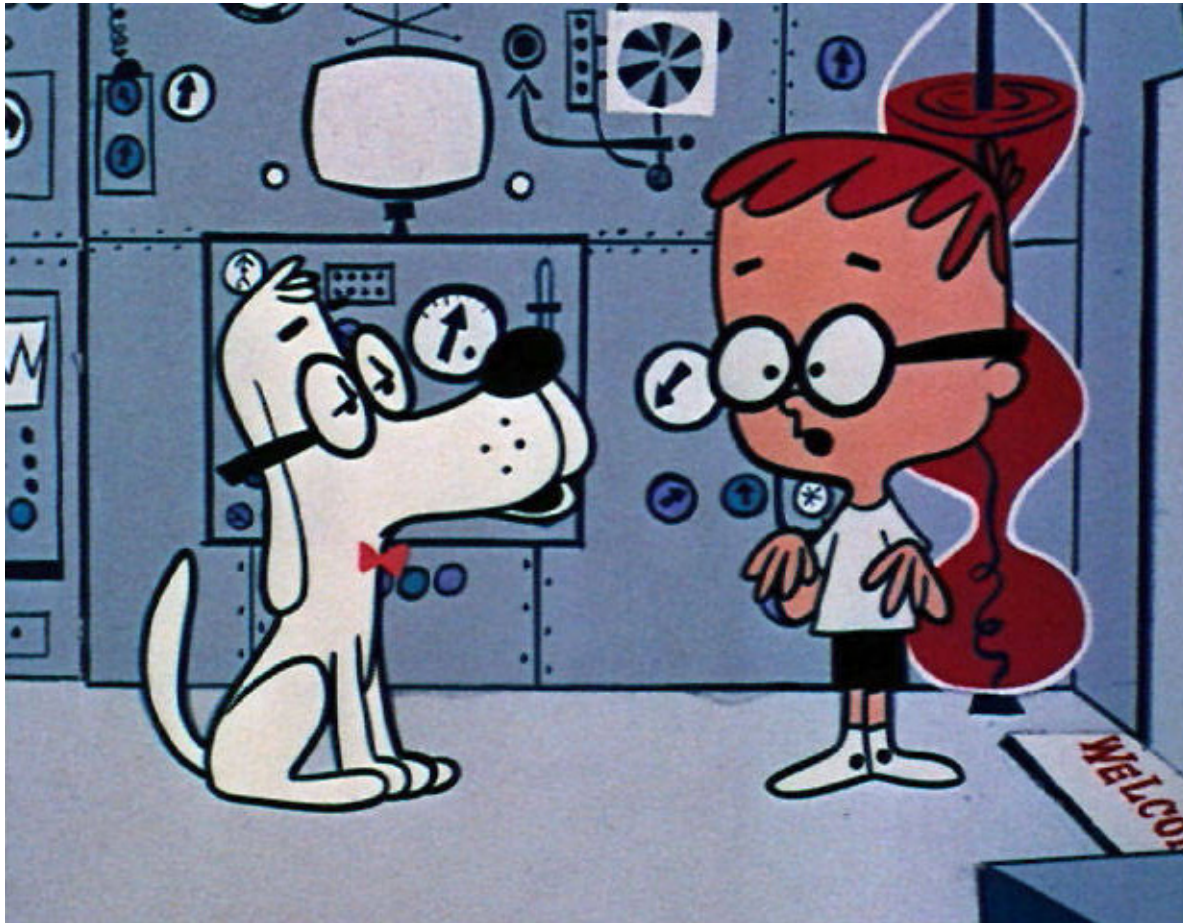
**Bill & Melinda Gates Chair in
Computer Science & Engineering
University of Washington**

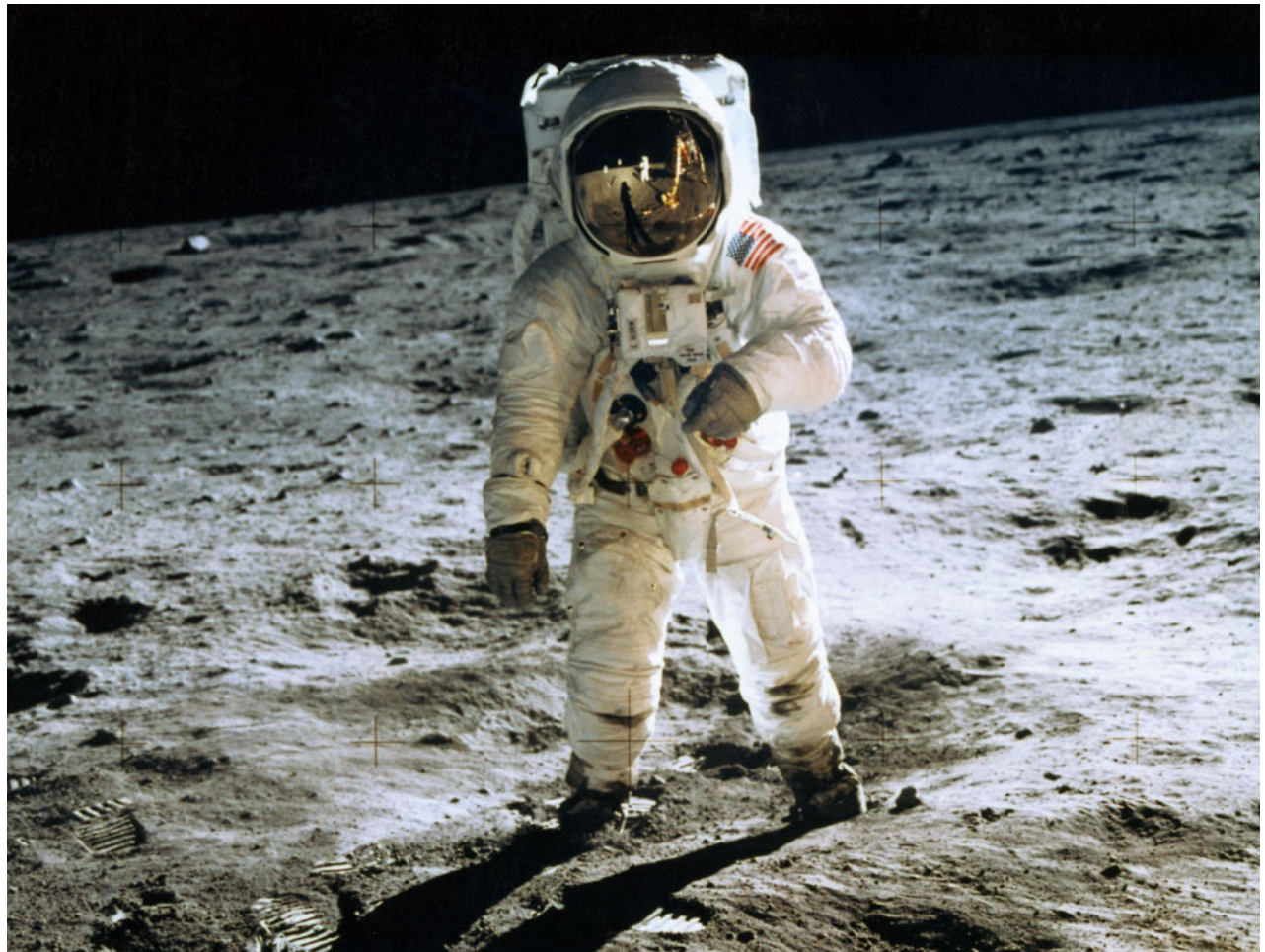
NCWIT Aspirations Awards

March 2015



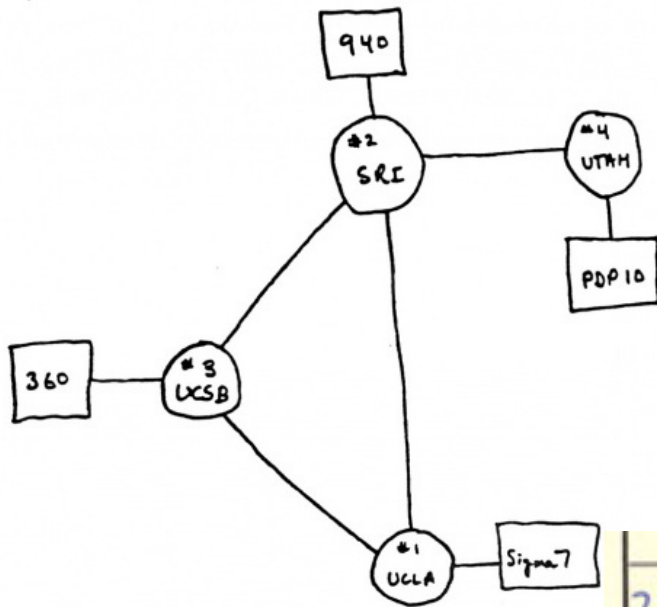
Forty five years ago ...











THE ARPA NETWORK
DEC 1969
4 NODES

29 OCT 69	2100	LOADED OP. PROGRAM	CSK
		FOR BEN BARKER	
		BBV	
		<hr/>	
	22:30	Talked to SRI	CSK
		Host to Host	
		Left op. program	CSK
		running after sending	
		a host dead message	
		to imp.	



With 4+ decades of hindsight, which had
the greatest impact?

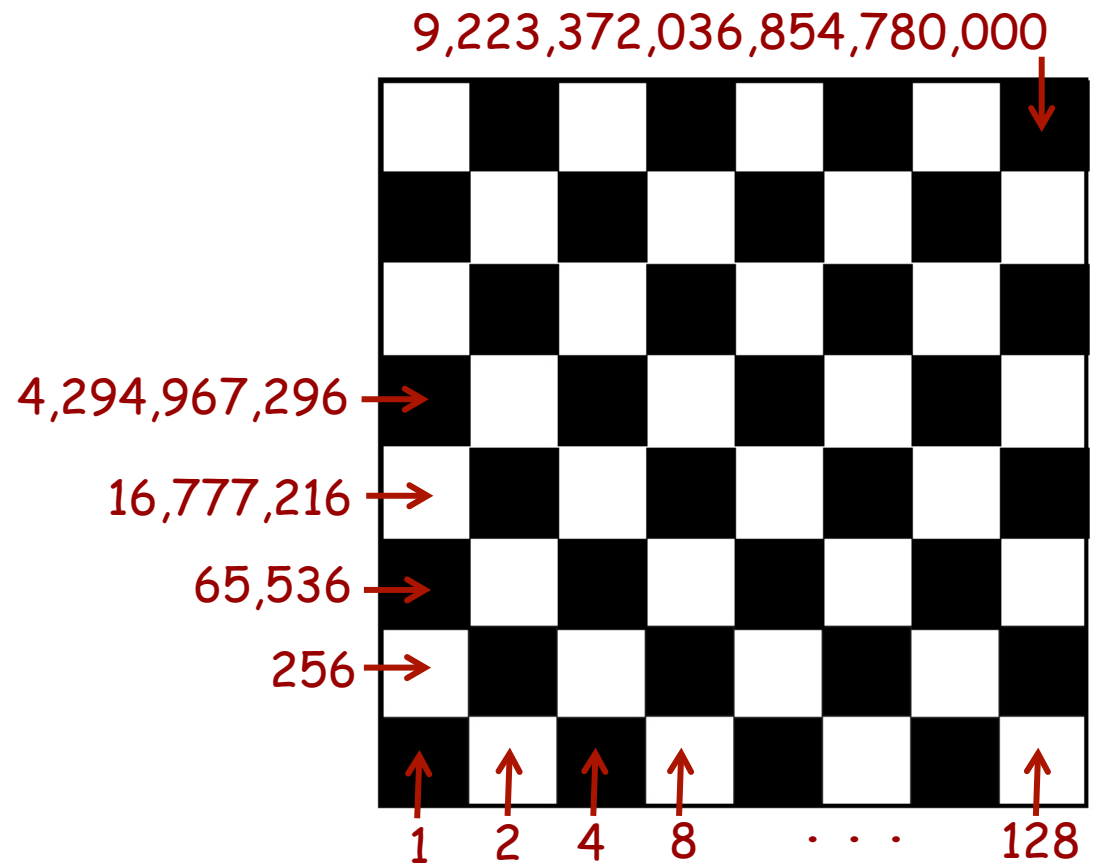
- Unless you're big into Tang and Velcro (or sex and drugs), the answer is clear ...



- And so is the reason ...

EXPONENTIALS  **US**

Exponentials are rare – we're not used to them, so they catch us unaware

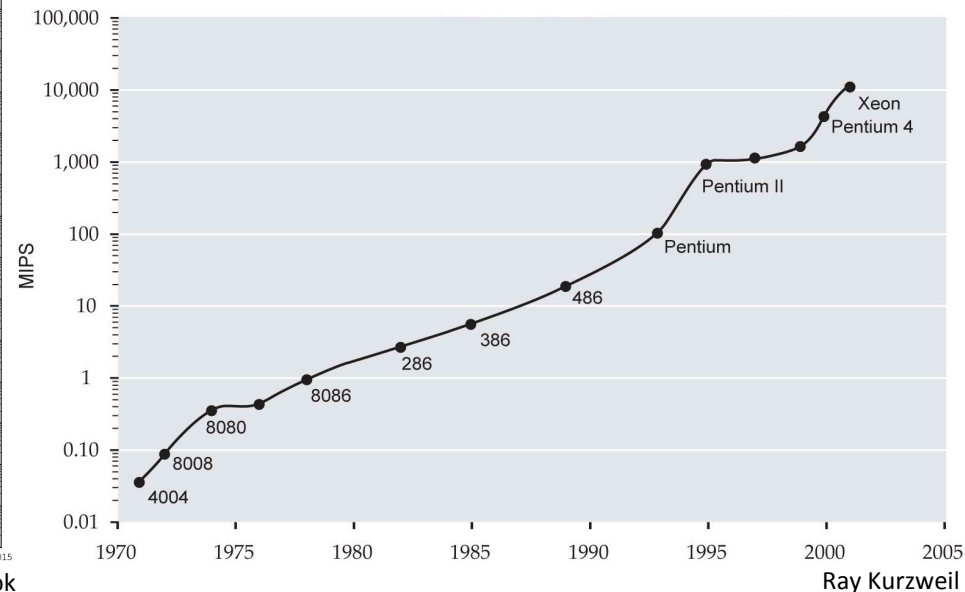
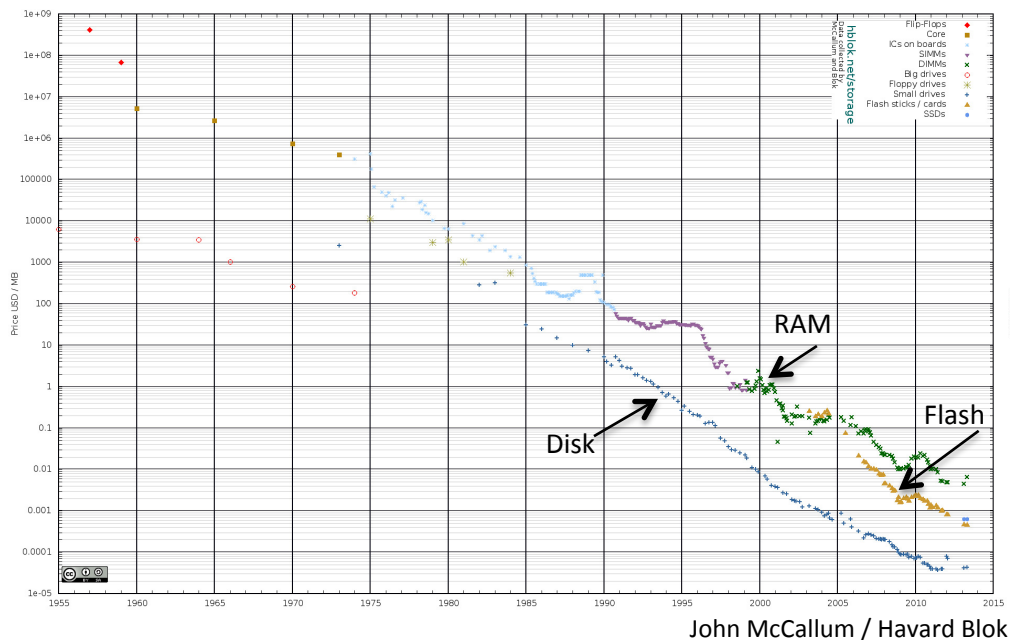


Every aspect of computing has experienced exponential improvement

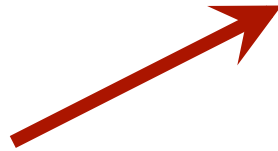
- Processing capacity
- Storage capacity
- Network bandwidth
- Sensors
- Astonishingly, even algorithms in some cases!

You can exploit these improvements in two ways

- Constant capability at exponentially decreasing cost
- Exponentially increasing capability at constant cost







The 1970s to today



1970 Ford Mustang



2014 Ford Mustang

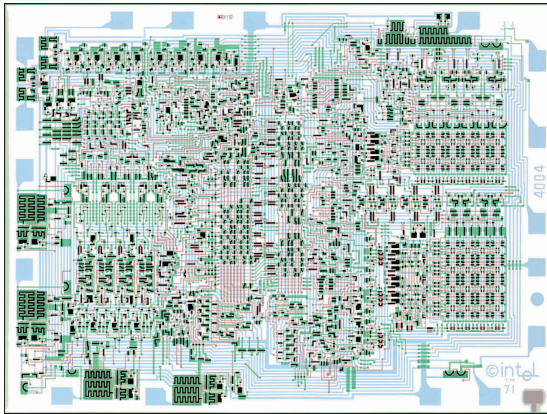
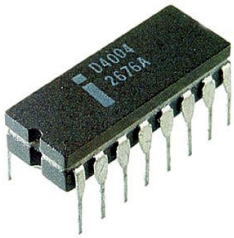
Size: roughly comparable

Speed: roughly comparable

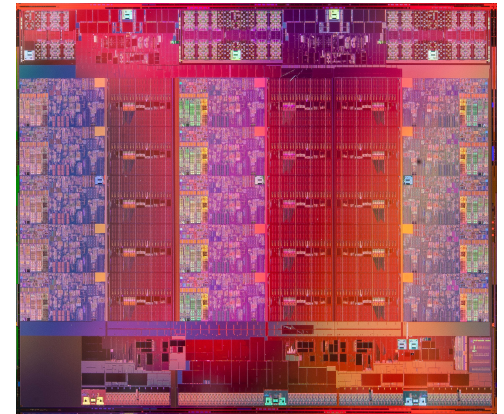
Efficiency (MPG): roughly comparable

Value (cost relative to performance): roughly comparable

The 1970s to today



1971 Intel 4004
(2,300 transistors)



2014 Intel Xeon
(4,300,000,000 transistors)

Size: area occupied by a transistor reduced by 1,000,000x

Speed: operations per second increased by 100,000x

Efficiency (operations per watt): improved by 6,750x

Value (dollars per instruction): improved by 2,700x

The 1970s to today



1970 Ford Mustang

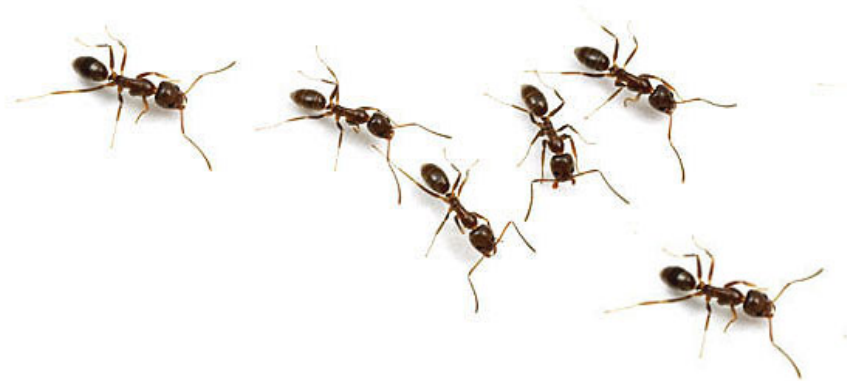


2014 Intel Xeon



What if cars had improved as rapidly as microprocessors?

The 1970s to today



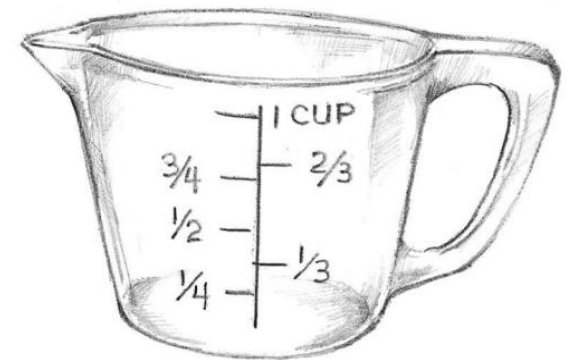
Size: A car would be smaller than an ant!
(About 1/5th of an inch long!)

The 1970s to today



Speed: A car would go 6,000,000 miles per hour!
(San Francisco to New York in 1.7 seconds!)

The 1970s to today



Efficiency: A car would get 100,000 miles per gallon!
(San Francisco to New York on 1/2 cup of fuel!)

The 1970s to today

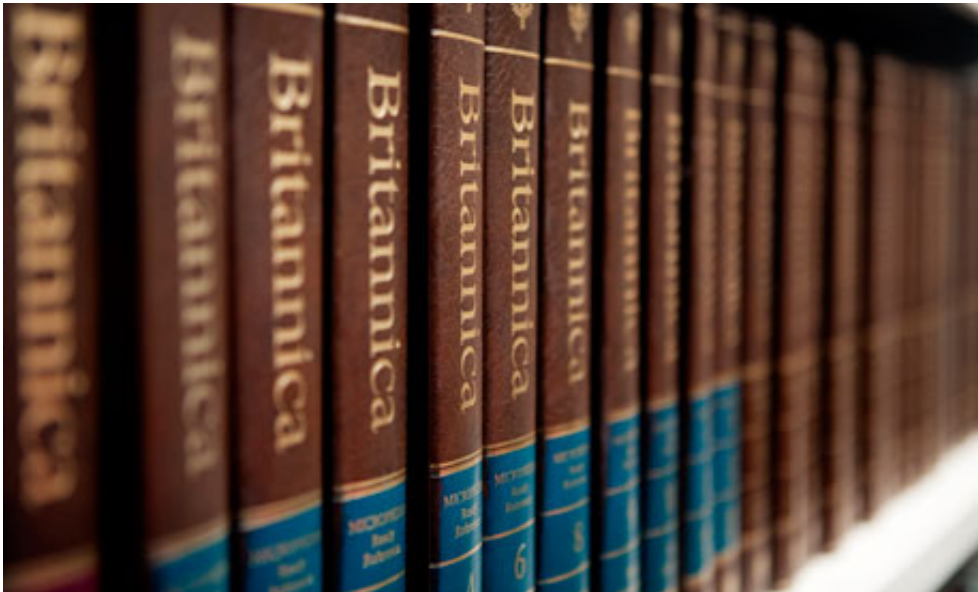


Cost: A car would cost less than \$10!

More then and now ...

- 20 years ago, microprocessors had 4 million transistors
 - Today they have 4 billion
- 20 years ago, the Internet had 1 million users
 - Today, it has 1 billion
- 20 years ago, only 15% of households had a computer
 - Today, nearly everyone owns a mobile phone
 - In the past year, more than half of all mobile phones purchased worldwide were smartphones – putting the Internet in the owner's pocket

Searching for information



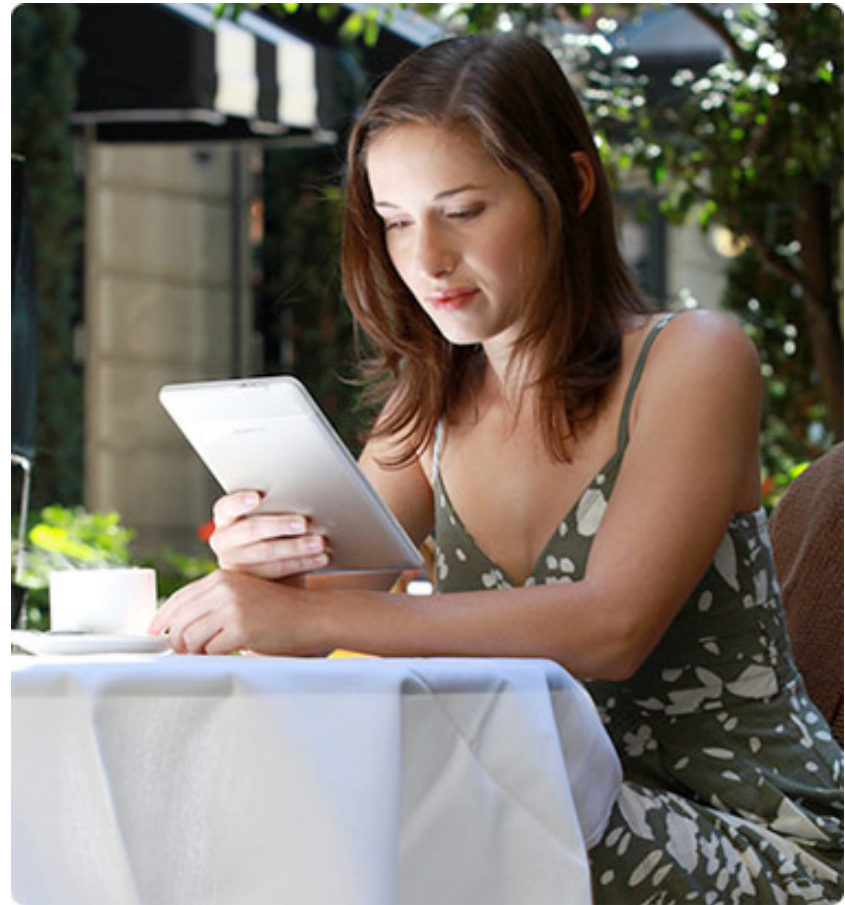
Searching for directions



Searching for love



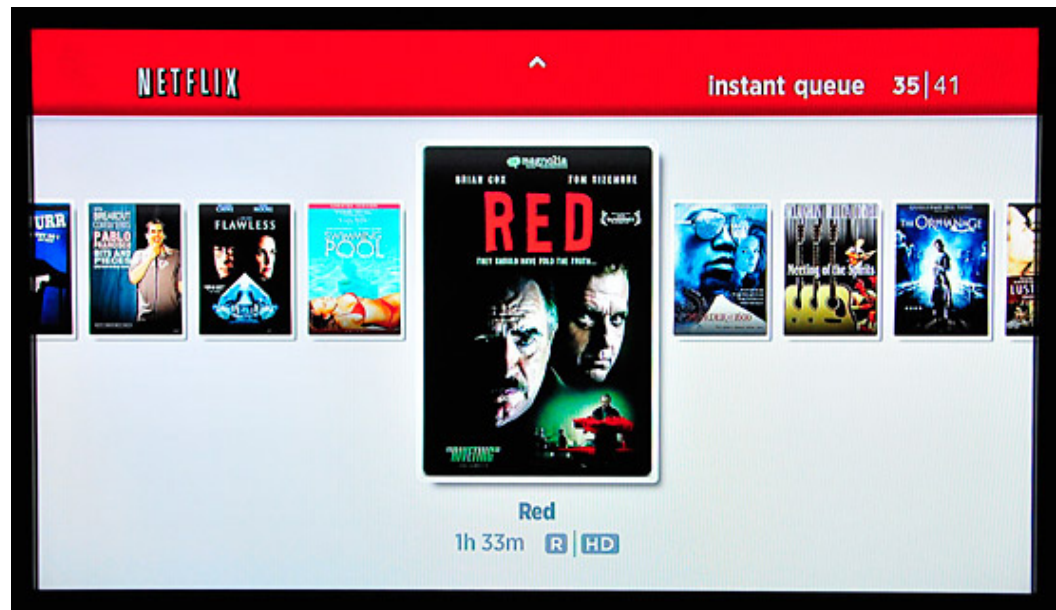
Reading books



Listening to music



Watching movies



During the decade of the 2000's ...



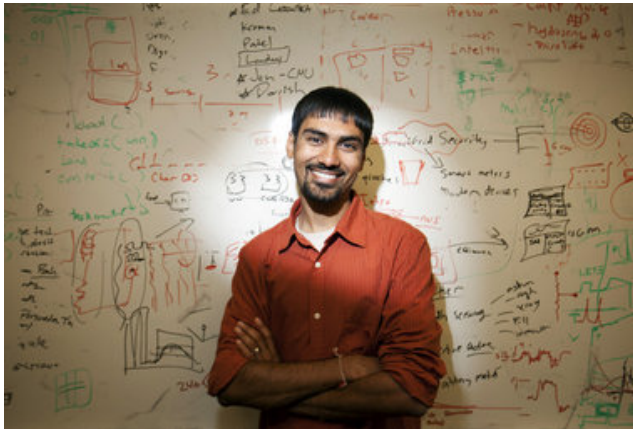
- Search
- Scalability
- Digital media
- Mobility
- eCommerce
- The Cloud
- Social networking and crowd-sourcing

During the current decade ...

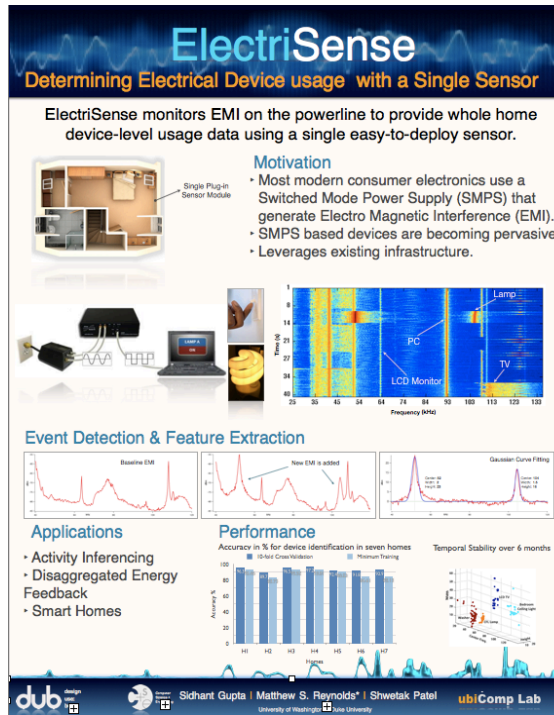


- Smart homes
- Smart cars
- Smart health
- Smart robots
- Smart crowds and human-computer systems
- Smart learning
- Smart interaction (virtual and augmented reality)
- Smart cities
- Smart discovery

Smart homes (the leaf nodes of the smart grid)



Shwetak Patel,
University of Washington
2011 MacArthur Fellow



Smart cars

DARPA Grand Challenge



DARPA Urban Challenge

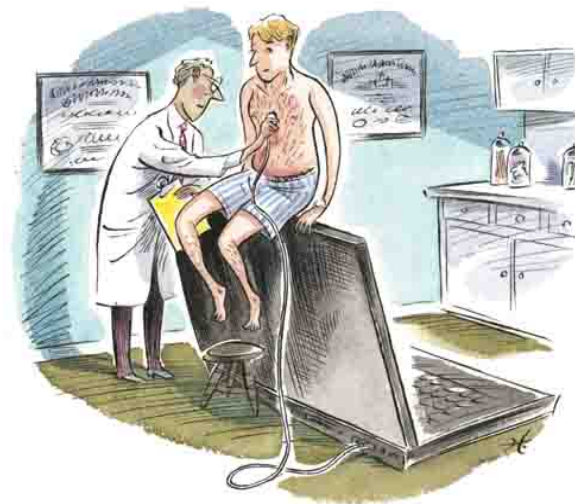


Google Self-Driving Car

Smart health



Larry Smarr – “quantified self”



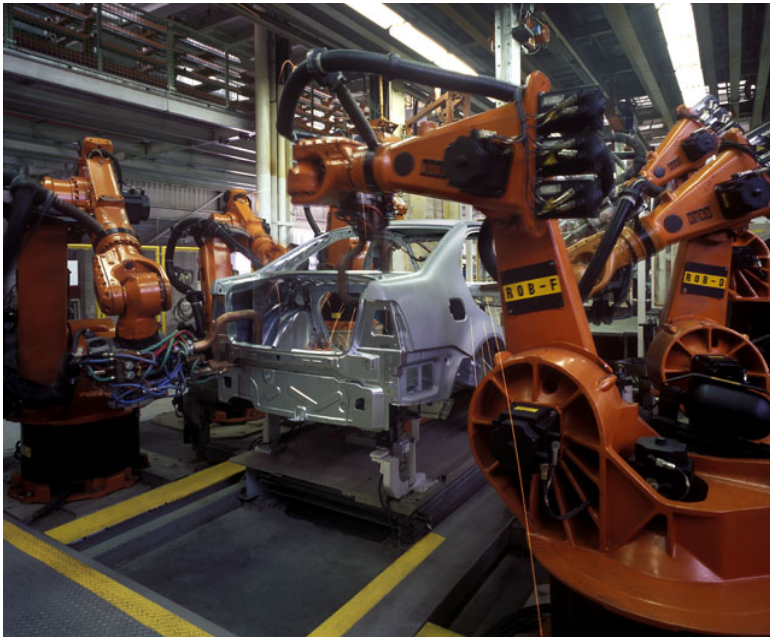
Evidence-based medicine



PIONEER 100
HUNDRED PERSON WELLNESS PROJECT
Institute for Systems Biology

P4 medicine

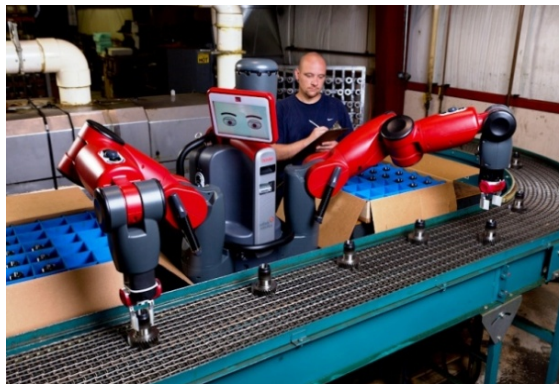
Smart robots



iRobot®



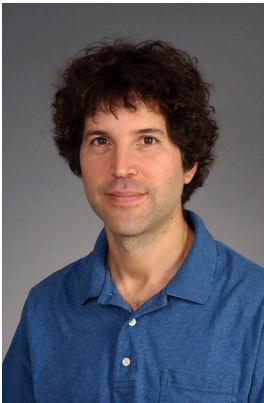
rethink
robotics



Smart crowds and human-computer systems



Zoran Popovic,
UW Computer Science &
Engineering



David Baker,
UW Biochemistry

The screenshot shows the Foldit website interface. At the top, there's a green header with the 'foldit BETA' logo and the tagline 'Solve Puzzles for Science'. A clock shows '02:59:51 GMT'. Navigation links include 'BLOG', 'GROUPS', 'PLAYERS', 'PUZZLES', 'RECIPES', 'FORUM', 'WIKI', 'FEEDBACK', and 'ABOUT'. The main content area features a large 3D protein structure with a text box that says 'Click to learn how you contribute to science by playing Foldit.' Below this, a 'What's New' section titled 'Small Update' contains text about stability fixes and scoring improvements. On the right, there's a 'GET STARTED: DOWNLOAD' section with buttons for 'Win Beta', 'Mac Beta', and 'Linux Beta'. Below that is a 'RECOMMEND FOLDIT' section with a text input and a 'Send' button. At the bottom right is a 'USER LOGIN' section with fields for 'Username' and 'Password', a 'Log in' button, and links for 'Create new account', 'Request new password', and 'Sign in using Facebook' (with a 'Connect with Facebook' button).

Smart learning



Zoran Popovic,
UW Computer Science &
Engineering



Algebra Challenge

[Introduksjon](#) [Organisering](#) [Vanlige spm](#) [Blog](#) [Kontakt](#) [Statistikk](#)



7 700 000

Likninger løst

DET HENDTE:
13. - 17. Januar 2014

36 110 elever løste likninger sammen
1711 klasser deltok i utfordringen
93% oppnådde "mestring" innen 1½ time

En uforglemmelig matematikktime!

Fra 13. til 17. Januar 2014 ble en tilpasset versjon av [DragonBox](#) gjort gratis tilgjengelig for alle skoler i Norge. Les om [hvordan det gikk her](#).

[Ressurser til hjelp](#)

[Ekstra-materiale](#)



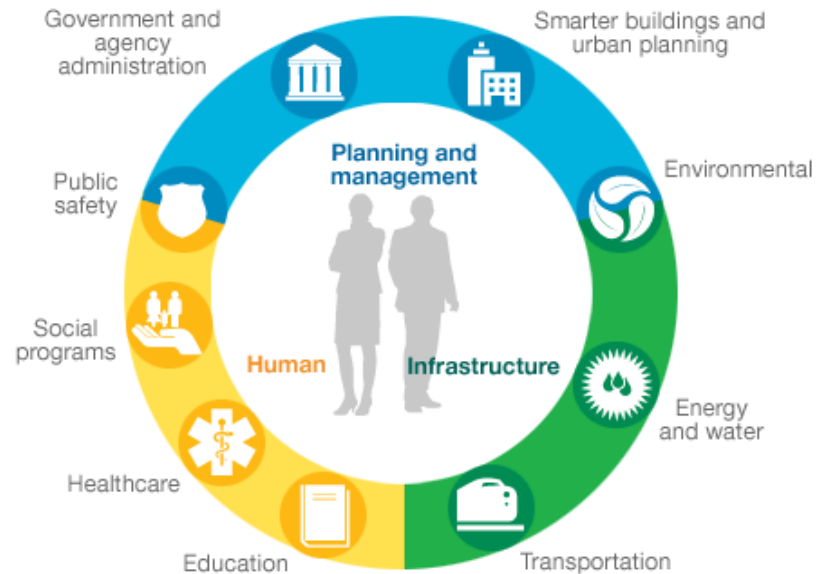
[Kontakt oss](#)

Smart interaction



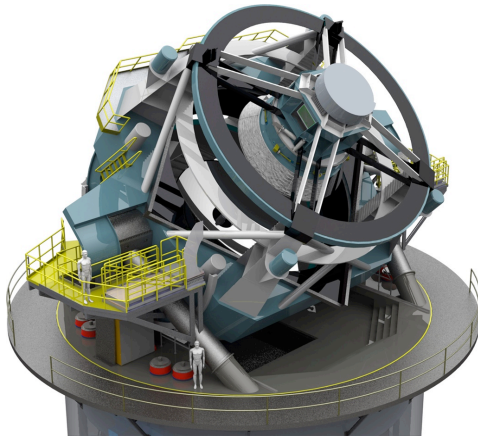
KINECT[™]
for  **XBOX** 360.

Smart cities

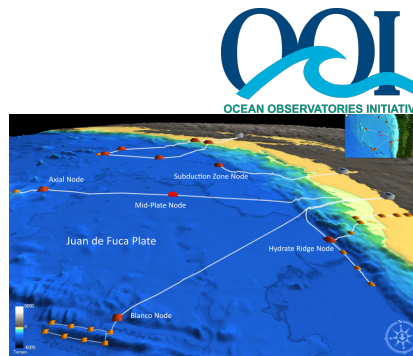


Smart discovery (data-intensive discovery, or *eScience*)

Nearly every field of discovery is transitioning from “data poor” to “data rich”



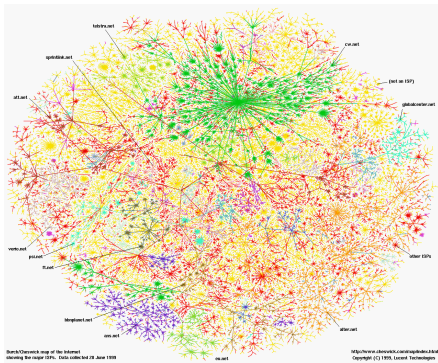
Astronomy: LSST



Oceanography: OOI



Physics: LHC



Sociology: The Web



Biology: Sequencing

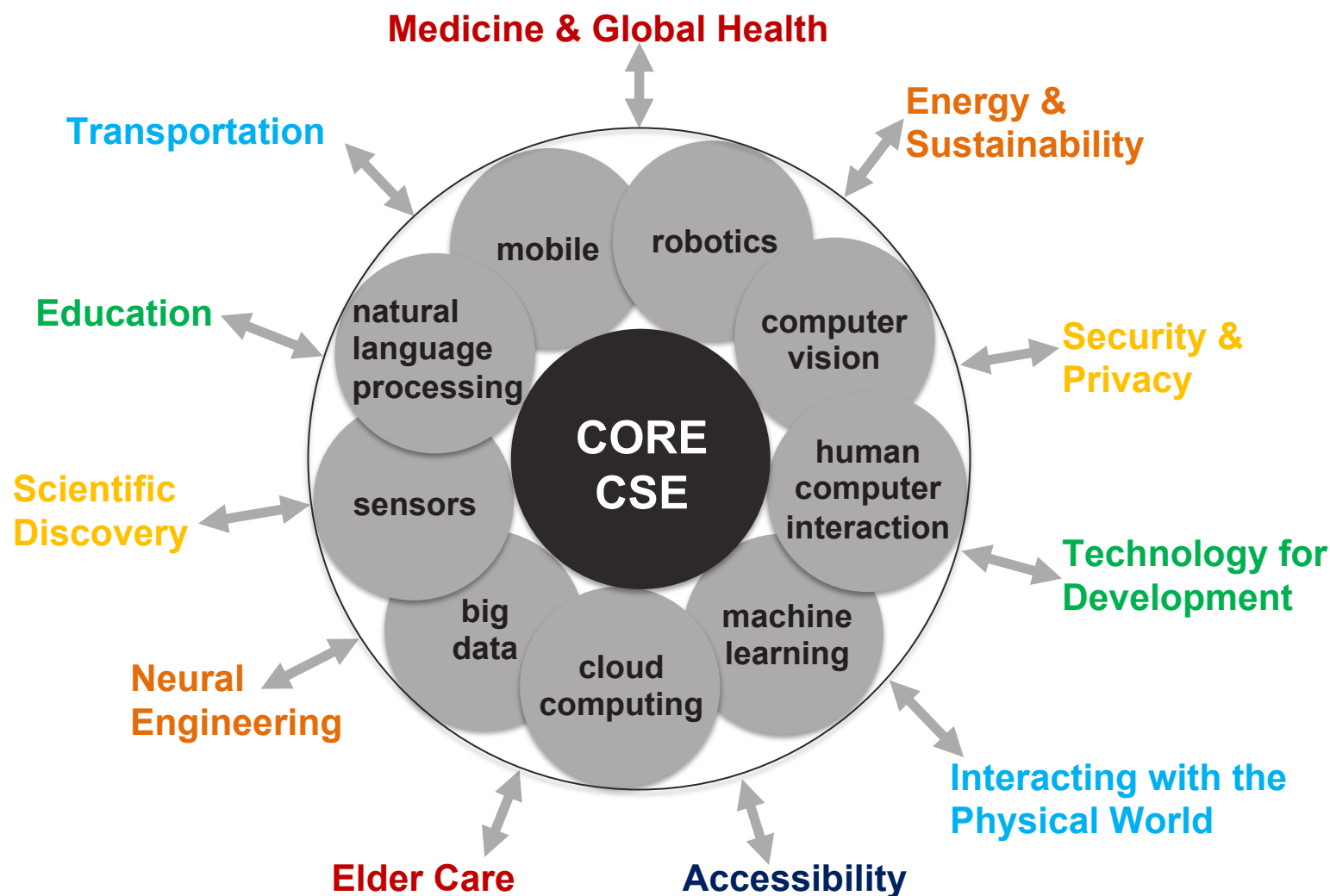


Economics: POS terminals



Neuroscience: EEG, fMRI

A 21st century view of Computer Science: A field that's unique in its societal impact

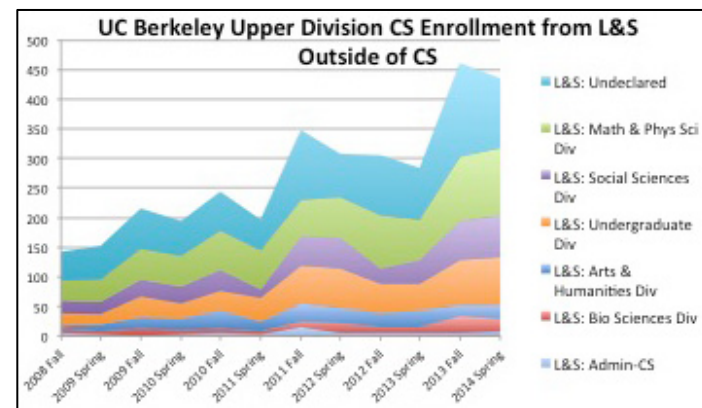
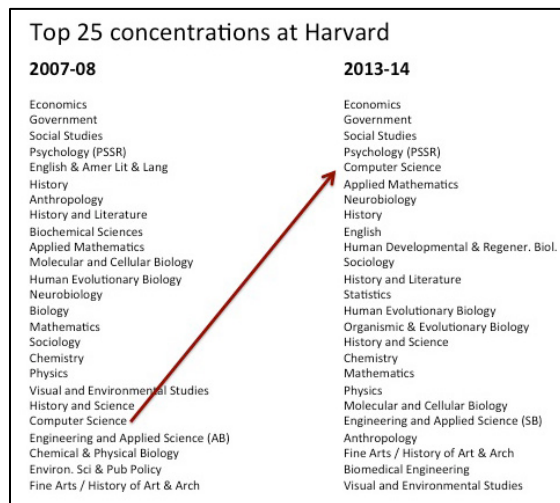
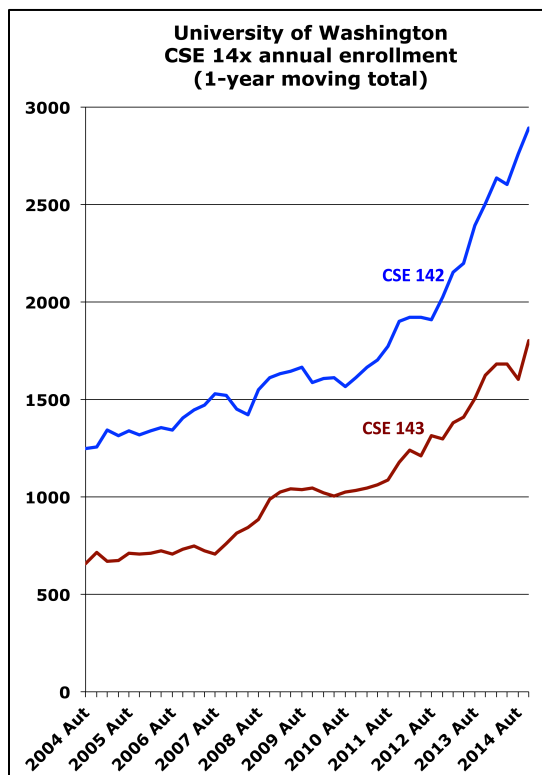



Computer Science: The ever-expanding sphere



Students are figuring this out!

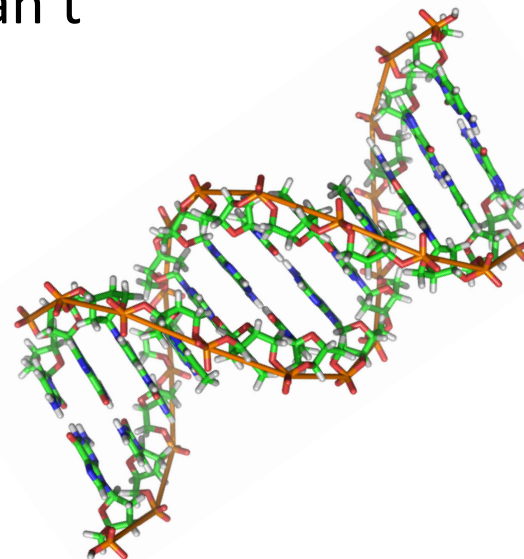
- Demand is booming at colleges and universities nationwide
 - For introductory courses
 - For the major
 - For upper-division and graduate courses by non-majors



- Demand for introductory courses: Students are realizing that every 21st century citizen needs to have facility with “computational thinking” – problem analysis and decomposition (stepwise refinement), abstraction, algorithmic thinking, algorithmic expression, stepwise fault isolation (debugging), modeling
 - Computational thinking is not “this particular operating system” or “that particular programming language.”
 - Computational thinking is not even programming. It’s a mode of thought – a way of approaching the world.
 - Programming is the hands-on, inquiry-based way that we teach computational thinking and the principles of computer science.
- 
- A vibrant graphic showing a silhouette of a human head in profile, facing left. The interior of the head is filled with several interlocking orange gears. Surrounding the head are numerous small, colorful circular icons representing various fields of study: science (DNA helix, atom, microscope, test tube, globe), mathematics (numbers, fractions, square root symbols, pi symbol), music (musical notes), art (palette, paintbrush), and general education (book, lightbulb, person running). The background is black, making the bright colors stand out.



- Demand for upper-division and graduate courses by non-majors: Students are realizing that computer science is great preparation for anything! Fields from Anthropology to Zoology are becoming *information* fields, and that those who can bend the power of the computer to their will – computational thinking, but also computer science in greater depth – will be positioned for greater success than those who can't
 - Data science is a perfect example

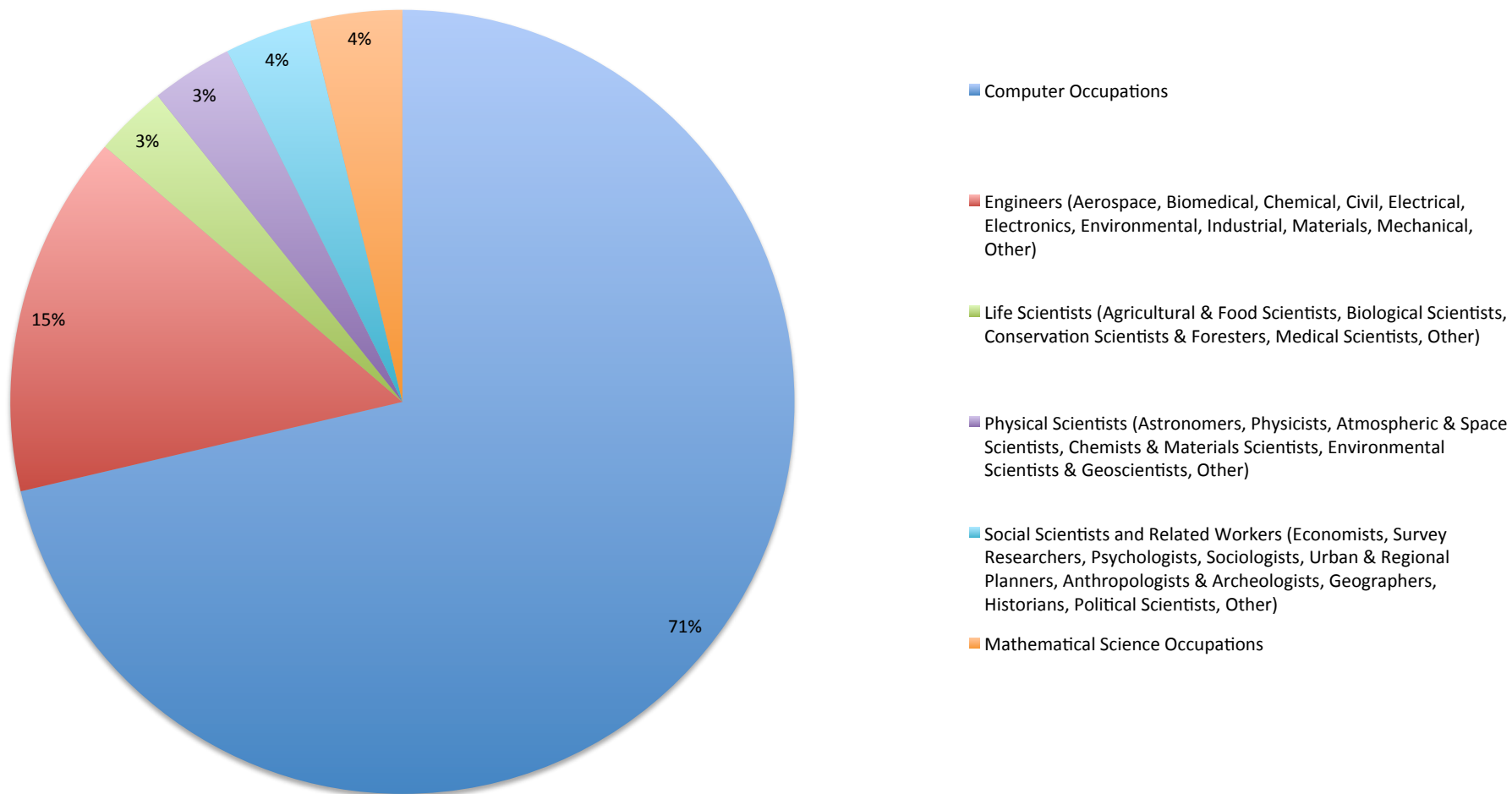


- Demand for the major: Students are realizing that computer science is not Dilbert – it's an intellectually exciting, highly creative and interactive, “power to change the world” field



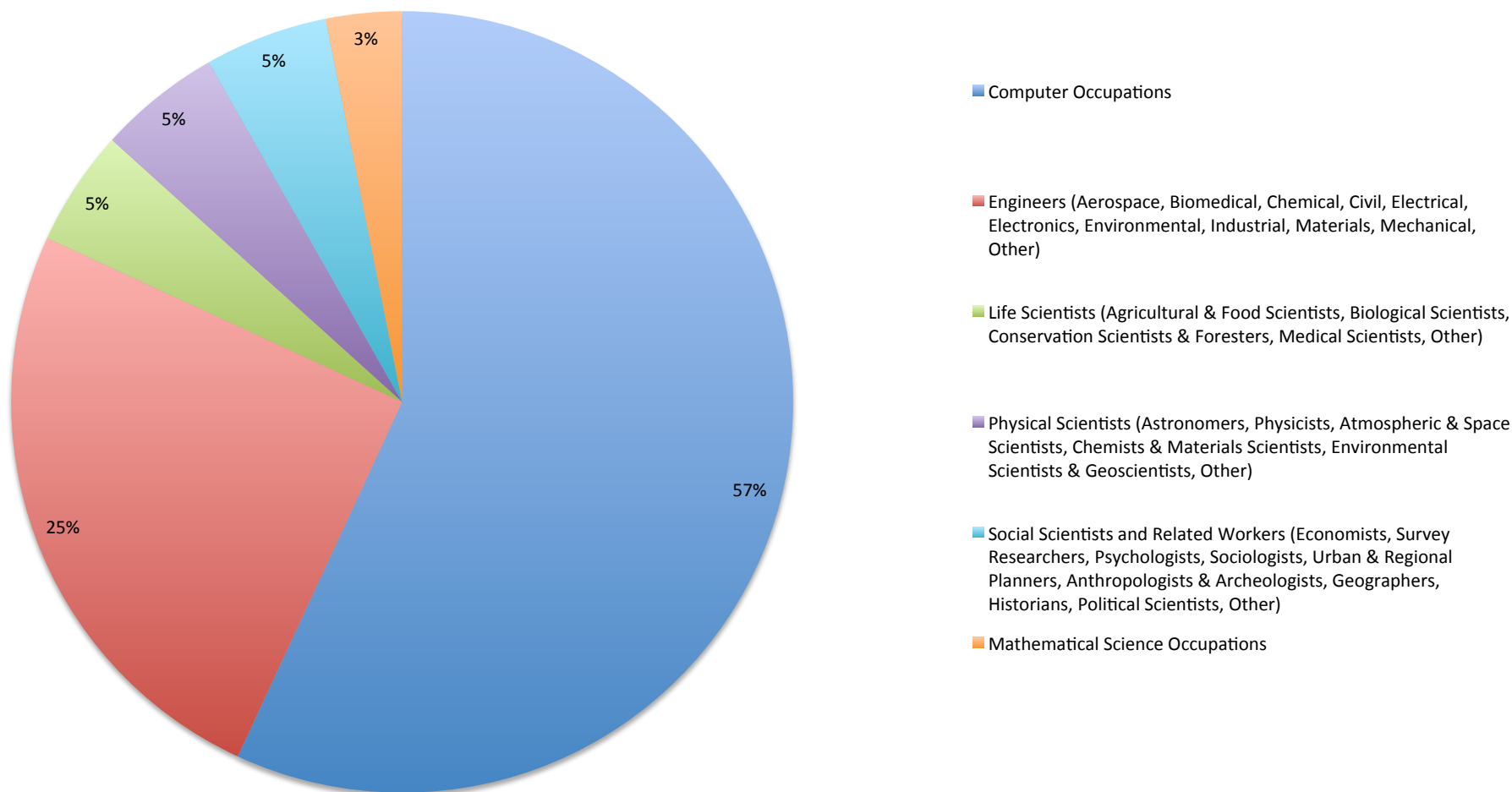
- Students are realizing that pretty much all of the STEM jobs are in computer science
 - While fluency with computational thinking and with computer science are important to all fields, *the job prospects in the field of computer science itself are extraordinary*
 - The U.S. Bureau of Labor Statistics recently released its job projections for the decade 2012-2022. Computer occupations will be responsible for 71% of *all* the job growth in *all* fields of STEM (Science, Technology, Engineering, and Mathematics) – the many dozens of fields that comprise the life sciences, the physical sciences, the social sciences, engineering, and the mathematical sciences – and for 57% of all available jobs, whether newly-created or available due to replacement
 - In Washington State, the workforce gap in computer science is greater than the workforce gap in *all other fields* (not just STEM fields!) combined

Job Growth, 2012-22 - U.S. Bureau of Labor Statistics
Computer Occupations = 71% of all STEM



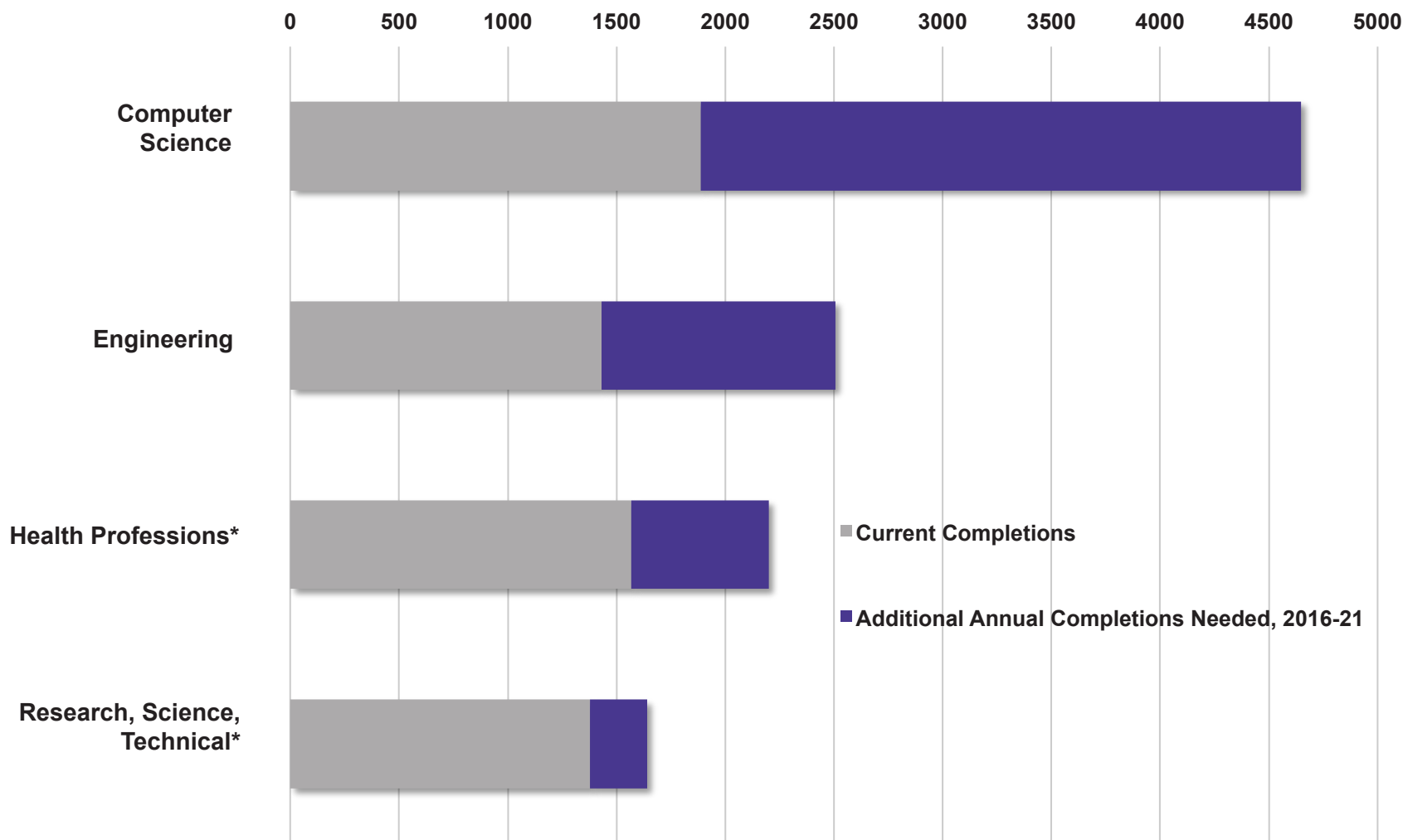
Job Openings (Growth And Replacement), 2012-22 - U.S. Bureau of Labor Statistics

Computer Occupations = 57% of all STEM



High Demand Fields in WA State, Baccalaureate Level & Above

WSAC / SBCTC / WTECB, October 2013



*Gap exists at the graduate and/or professional level only

UW Computer Science & Engineering

- Ranked among the top 10 programs in the nation (of >200)
 - MIT, Stanford, Berkeley, Carnegie Mellon, Illinois, Cornell, Washington, Princeton, Georgia Tech, Texas, Caltech, Wisconsin, UCLA, Michigan, Columbia, UCSD ...
- Two undergraduate programs
 - Computer Science (College of Arts & Sciences)
 - Computer Engineering (College of Engineering)
- > 300 degrees per year
 - ~200 Bachelors (growing to ~250)
 - ~85 Masters
 - ~25 Ph.D.

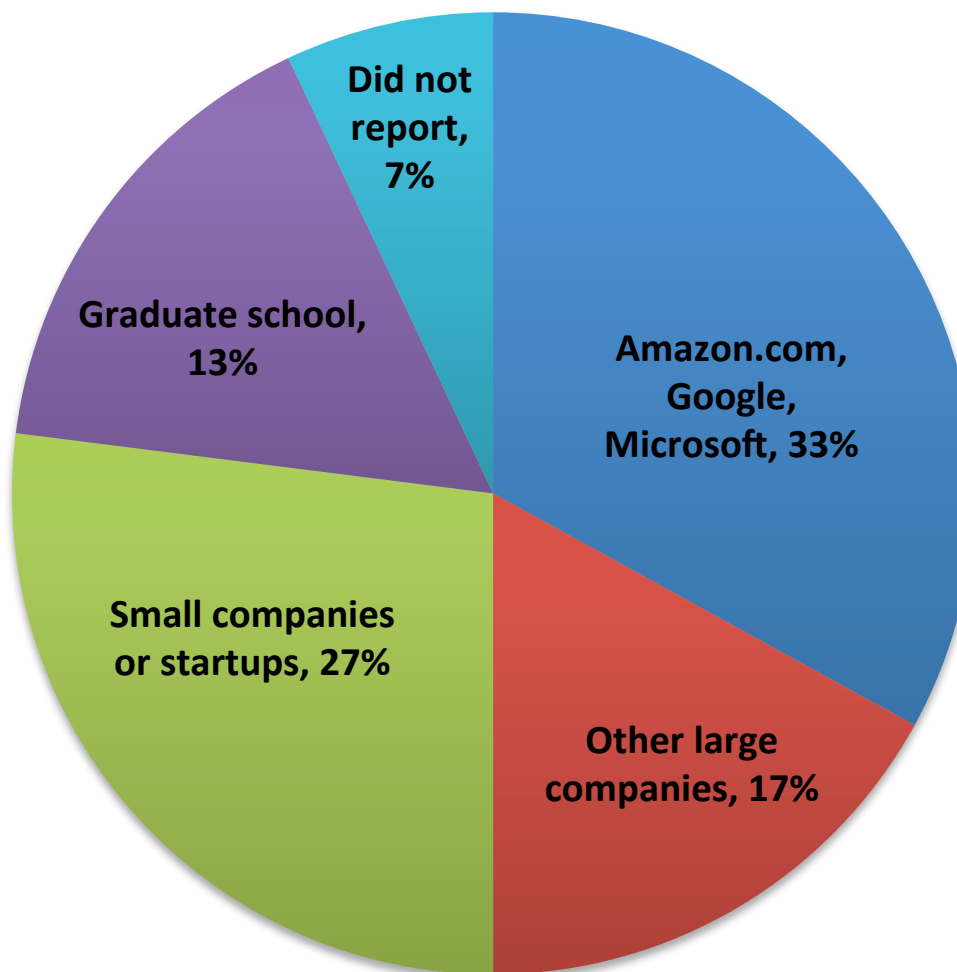


- Extraordinary students
 - Fully 1/3 of the UW class medalists since 2000 have been CSE majors
 - Our “fair share” would be 2%
 - 3 of the past 5 Graduate School Medal recipients
 - “Academic expertise and social awareness”

- A deep commitment to providing a top-tier education
 - Winner of 5 UW Distinguished Teaching Awards
 - Winner of the inaugural UW Brotman Award for Instructional Excellence
 - Winner of two UW Distinguished Graduate Mentor Awards
 - In a typical quarter, CSE has 2/3's of the top-performing instructors in the 10-department UW College of Engineering, according to student course evaluations
 - 9 of the top 10 instructors in the most recent quarter

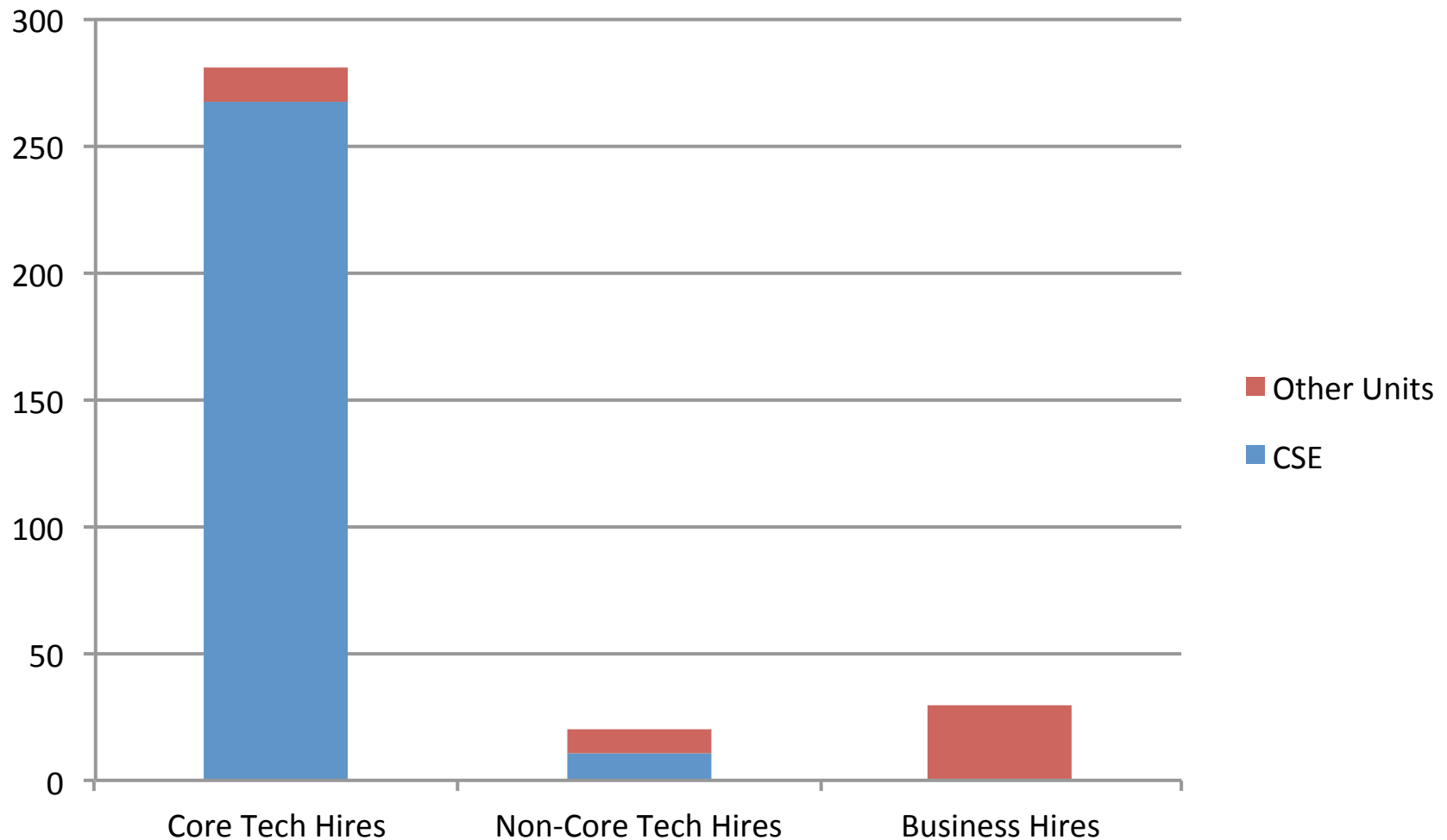
- We produce students who can *design and build stuff*
 - Emphasis on teamwork and design
 - 80% of undergraduates do at least one internship
 - 50% of undergraduates participate in faculty-guided research
 - #1 school in the nation in students recognized in the past 10 years in the Computing Research Association “Outstanding Undergraduate Researchers Award” competition
 - A top-5 supplier of students to Amazon.com, Google, and Microsoft (along with MIT, Stanford, Berkeley, and Carnegie Mellon)
 - The predominate supplier to many leading smaller firms headquartered here

2012-13 UW CSE Student Destinations



Tech companies that can be choosy, choose CSE

2011-12 Permanent & Internship Hires from UW by Amazon.com, Facebook, Google, and Microsoft



Why a research-intensive university?



What can we uniquely do?

- Get students into the lab
- Make them our partners in discovery
- Prepare them for life-long learning at the forefront of knowledge and society
 - *There is no field in which this is more important!*

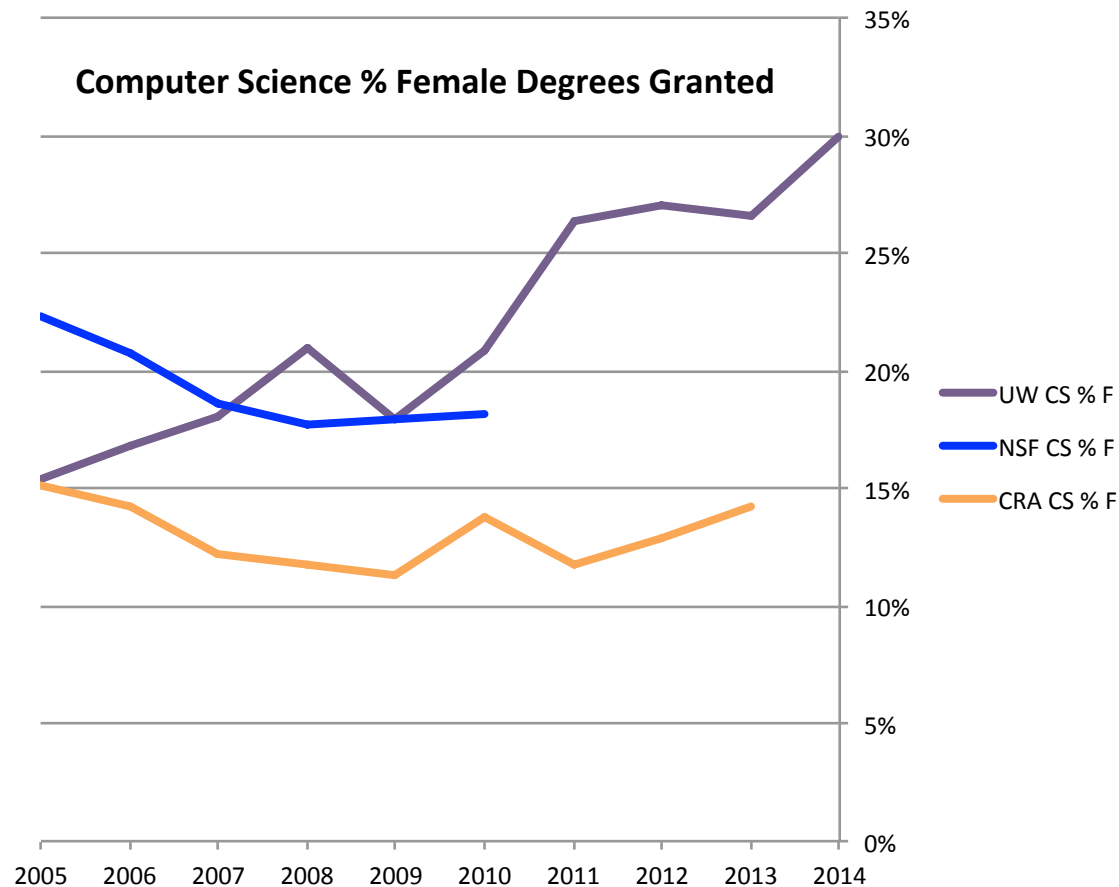
Community: Undergraduate TAs



Community: Grace Hopper Celebration of Women in Computing



Community: Grace Hopper Celebration of Women in Computing



Community: Spring picnic



Community: Summer Day Camps for Middle School Girls



There are some OK reasons to go out-of-state for college

- Get away from your boyfriend/girlfriend
- Get away from your parents
- Get away from the rain

**Getting a better Computer Science education
is not one of them!**



- Erin Earl
 - Overlake School -> Robinson Center Transition School -> Robinson Center Early Entrance Program
 - Triple major in Music, Piano Performance, Computer Science
 - UW Dean's Medal for the Arts
 - Indiana University Conservatory (3 months)
 - Google (5 years)
 - Harvard Law School
 - Clerkship in the United States District Court for the Eastern District of Virginia
 - Clerkship in the United States Court of Appeals for the Ninth Circuit
 - Headed home to Seattle this fall to focus on privacy and security in Perkins Coie's commercial litigation group

- Raymond Zhang
 - Robinson Center Transition School -> Robinson Center Early Entrance Program
 - Double major in Biology, Computer Science
 - Undergraduate research in computational biology
 - Goldwater Scholar
 - Piano performances at Carnegie Hall, Lincoln Center, Benaroya Hall
 - 2013 UW Dean's Medal in Engineering
 - Google



- Christophe Bisciglia
 - Gig Harbor High School
 - UW CSE
 - Google (5 years)
 - Cloudera, Inc. (Founder) (2.5 years)
 - WibiData (Founder and CEO)



- Emma (Lynch) Nixon
 - Ballard High School '07
 - UW CSE '11
 - Undergraduate research on Games for Learning – Refraction
 - SDE intern at Microsoft
 - SDE at Microsoft



Preparing for CSE

- Not necessarily a high school computer science course!
- Deep comfort with algebra
- Scientific reasoning
- Reading comprehension
- Attention span
- Resilience when faced with challenges

Is this a great time or what?

