



CS10: The Beauty and Joy of Computing

Lecture #23 Future of Computing



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INDIAN POWER GRID FAILURE

Yesterday 370M people in Northern India were without electricity for about 6 hours after a grid failure. (Similar problems have happened all over the world, but this was the biggest by far to date.)



<http://www.thehindu.com/news/national/article3702075.ece>



Lecture Overview

- Where will today's computers go?
- Quantum Computing
- DNA Computing
- Biological Machines
- Optical Computing
- Smart Grid + Energy





Computer Technology - Growth!

■ Processor

- Speed 2x / 2 years (since '71)
- 100X performance last decade
- Soon: 4 GHz, 32 Cores

■ Memory (DRAM)

- Capacity: 2x / 2 years (since '96)
- 64x size last decade.
- Soon: 128 GibiBytes

■ Disk

- Capacity: 2x / 1 year (since '97)
- 250X size last decade.
- Soon: 16 TeraBytes

Kilo (10^3) & Kibi (2^{10})



Mega (10^6) & Mebi (2^{20})



Giga (10^9) & Gibi (2^{30})



Tera (10^{12}) & Tebi (2^{40})



Peta (10^{15}) & Pebi (2^{50})



Exa (10^{18}) & Exbi (2^{60})



Zetta (10^{21}) & Zebi (2^{70})



Yotta (10^{24}) & Yobi (2^{80})





Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta

- Kid meets giant Texas people exercising zen-like yoga. – Rolf O
- Kind men give ten percent extra, zestfully, youthfully. – Hava E
- Kissing Mentors Gives Testy Persistent Extremists Zealous Youthfulness. – Gary M
- Kindness means giving, teaching, permeating excess zeal yourself. – Hava E
- Killing messengers gives terrible people exactly zero, yo
- Kindergarten means giving teachers perfect examples (of) zeal (&) youth
- Kissing mediocre girls/guys teaches people (to) expect zero (from) you
- Kissing Mel Gibson, Teddy Pendergrass exclaimed: “Zesty, yo!” – Dan G





Peer Instruction



What was recently proposed to go after Yotta?
(i.e., 10^{27})

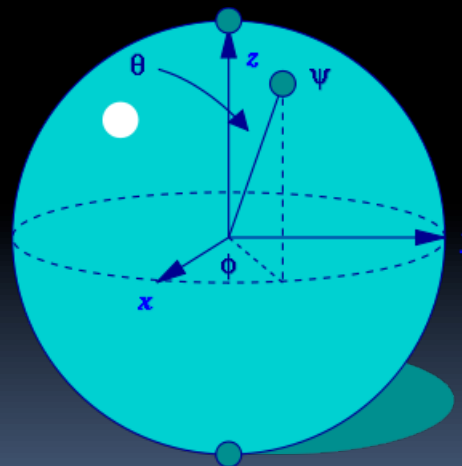
- a) Lotta
- b) Lotsa
- c) Wholelotta
- d) Hella
- e) Zillion





Quantum Computing (1)

- Proposed computing device using quantum mechanics
 - This field in its infancy...
- Normally: **bits**, which are either 0 or 1
- Quantum: **qubits**, either 0, 1 or “quantum superposition” of these
 - This is the key idea
- If you have 2 bits, they’re in exactly one of these:
 - 00, 01, 10 or 11
- If you have 2 qubits, they’re in **ALL** these states with varying probabilities



A Bloch sphere is the geometric representation of 1 qubit

en.wikipedia.org/wiki/Quantum_computer





Quantum Computing (2)

- **Imagine a problem with these four properties:**
 - The only way to solve it is to guess answers repeatedly and check them,
 - There are n possible answers to check,
 - Every possible answer takes the same amount of time to check, and
 - There are no clues about which answers might be better: generating possibilities randomly is just as good as checking them in some special order.
- ...like trying to crack a password from an encrypted file
- **A normal computer**
 - would take (in the worst case) n steps
- **A quantum computer**
 - can solve the problem in steps proportional to \sqrt{n}
- **Why does this matter?**





Quantum Computing (3)

- Say the password is exactly 72 bits (0/1)
- That's 2^{72} possibilities
- Let's say our Mac lab attacked the problem
 - 30 machines/lab * 8 cores/machine * 3 GHz (say 3 billion checks per second/core)
= 720,000,000,000 checks/sec/lab
= 720 Gchecks/sec/lab
- Regular computers
 - 2^{72} checks needed / 720 Gchecks/sec/lab
 ≈ 6.6 billion sec/lab
 ≈ 208 years/lab
- 72-qubit quantum computers in time \propto to $\sqrt{2^{72}} = 2^{36}$
 - 2^{36} checks needed / 720 Gchecks/sec/lab
 ≈ 0.1 sec/lab





DNA Computing

- **Proposed computing device using DNA to do the work**
 - Take advantage of the different molecules of DNA to try many possibilities at once
 - Ala parallel computing
 - Also in its infancy
- **In 2004, researchers claimed they built one**
 - Paper in "Nature"

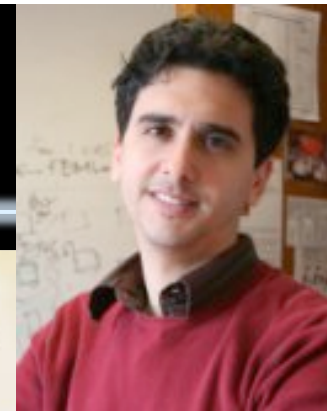


en.wikipedia.org/wiki/DNA_computing



Biological Machines

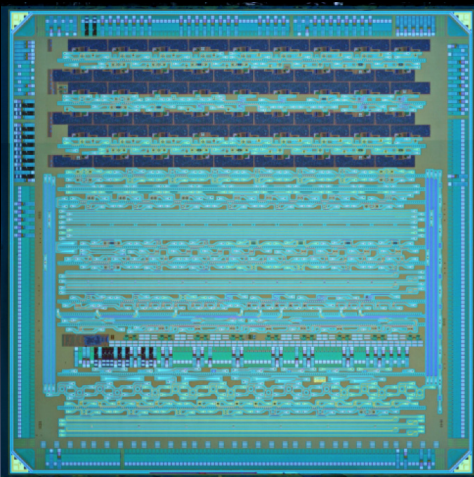
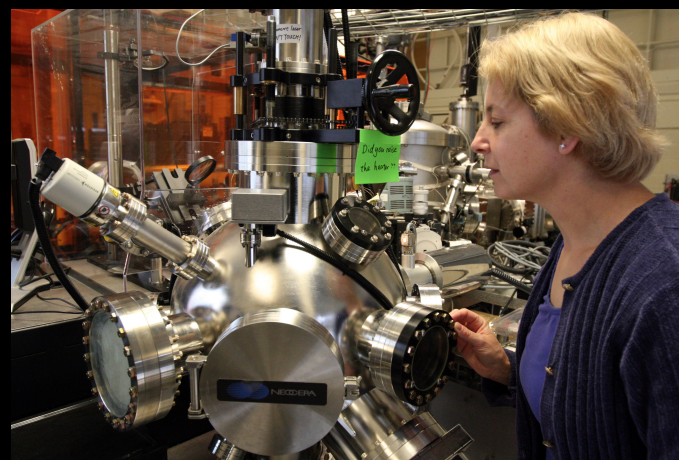
- Michel Maharbiz and his team at Cal have wired insects (here a giant flower beetle) and can control flight
 - Implanted as Pupa
- Vision
 - Imagine devices that can collect, manipulate, store and act on info from environment





Optical Computing

- Electro-optical hybrids
- Pure optical
- No-memory communication for multi-core processors!



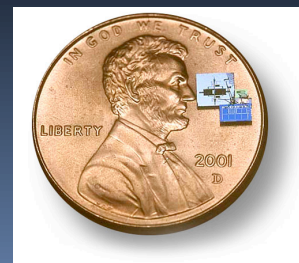
<http://web.mit.edu/newsoffice/topic/optical-computing.html>





Smart Grid + Energy

- Arguably the most important issue facing us today is climate change
- Computing can help
- Old: generators “broadcast” power
- New: “peer-to-peer”, with optimal routing
 - From: ability (to power)
 - To: according to need
- Energy
 - Computing helps with climate modeling and simulation
 - “Motes”, or “Smart dust” are small, networked computing measurement devices
 - E.g., could sense no motion + turn lights off





Summary

- What a wonderful time we live in; we're far from done
 - What about privacy?
- Find out the problem you want to solve
 - Computing can and will help us solve it
- We probably can't even imagine future software + hardware breakthroughs

