CS10
The Beauty and Joy of Computing

Lecture #24
Future of Computing

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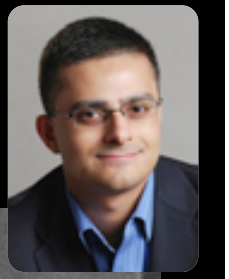
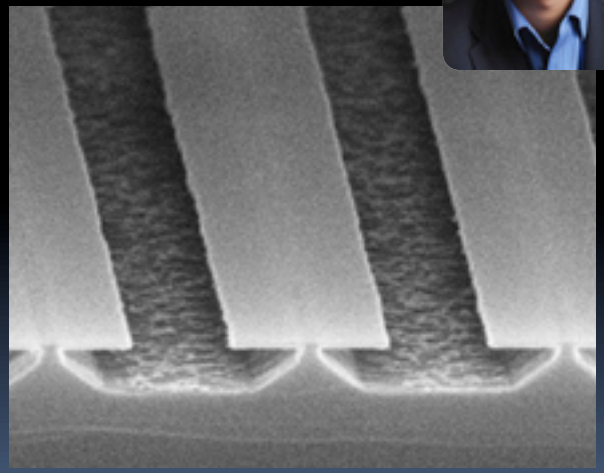


SILICON'S LONG GOODBYE

Prof Ali Javey's group's may have found the replacement for Silicon to make transistors. (Silicon will be too expensive and "leaky".) They can make "fast, low-power nanoscopic transistors out of a compound semiconductor material".



www.technologyreview.com/computing/26755/

Lecture Overview

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

Computer Technology - Growth!

- **Processor**
  - Speed 2x / 2 years (since '71)
  - 100X performance last decade
  - When you graduate: 4 GHz, 32 Cores
- **Memory (DRAM)**
  - Capacity: 2x / 2 years (since '96)
  - 64x size last decade.
  - When you graduate: 128 GibiBytes
- **Disk**
  - Capacity: 2x / 1 year (since '97)
  - 250X size last decade.
  - When you graduate: 8 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})

Peer Instruction

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

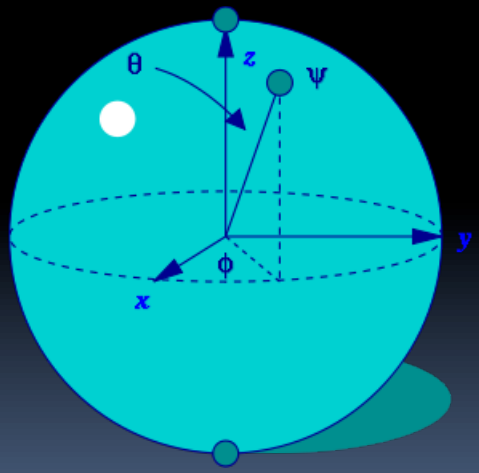
a) Lotta
b) Lotsa
c) Wholelotta
d) Hella
e) Zillion

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
- Kinky Mean Girls Teach Penis-Extending Zen Yoga
- Kissing Mel Gibson, Teddy Pendergrass exclaimed: "Zesty, yo!" – Dan G
- Kissing me gives ten percent extra zeal & youth! – Dan G (borrowing parts)

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

www.youtube.com/watch?v=Xq4hkzGZskA

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 α 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

www.eecs.berkeley.edu/~maharbiz/Cyborg.html

Biological Machines

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

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

Peer Instruction

What is the most exciting future for computing?

a) Evolution (not revolution) in computing architectures
b) Quantum computing
c) DNA computing
d) Energy
e) Wet computing (ala Matrix)

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