CS10
The Beauty and Joy of Computing

Lecture #24
Future of Computing

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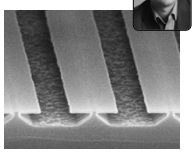
SILICON'S LONG GOODBYE

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

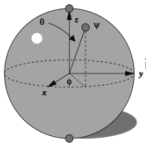
Kilo (10^3) & Kibi (2^{10})
↓
Mega (10^6) & Mebi (2^{20})
↓
Giga (10^9) & Gibi (2^{30})
↓
Tera (10^{12}) & Tebi (2^{40})
↓
Peta (10^{15}) & Pebi (2^{50})
↓
Exa (10^{18}) & Exbi (2^{60})
↓
Zetta (10^{21}) & Zebi (2^{70})
↓
Yotta (10^{24}) & Yobi (2^{80})

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)

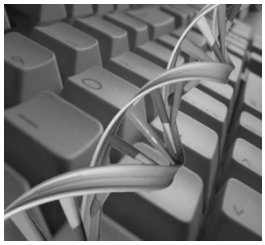
- **Imagine a problem with these four properties:**
  - The only way to solve it is to guess answers repeatedly and check them,
  - There are *n* possible answers to check,
  - Every possible answer takes the same amount of time to check, and
  - There are no clues about which answers might be better: 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"

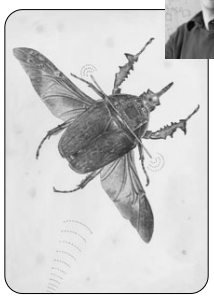


`en.wikipedia.org/wiki/DNA_computing`

`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

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**