The Beauty and Joy of Computing

Lecture #24
Future of Computing

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Amazon Prime Air!

Good: Deliver to your home in 30 minutes after click
Bad: Drones all over the air? Seriously?

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http://www.washingtonpost.com/blogs/the-
switch/wp/2013/12/01/amazon-wants-to-deliver-
      packages-in-30-minutes-with-drones/
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Lecture Overview

- Where will today's computers go?
- Quantum Computing
- DNA Computing
- Biological Machines

Computer Technology - Growth!

- **Processor**
  - Speed 2x / 2 years (since '71)
  - 100X performance last decade
  - When you graduate: 3 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: 16 TeraBytes

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

Both Google's and WolframAlpha's calculator can understand
and use "Hella" in their calculations!
`www.makehellaofficial.blogspot.com`

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**
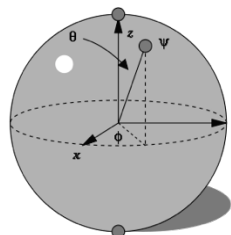
A Bloch sphere is the geometric representation of 1 qubit

`en.wikipedia.org/wiki/Quantum_computer`

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
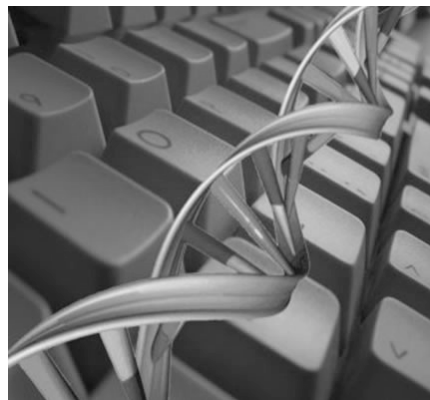 - ≈ 0.1 sec/lab

Quantum Computing Explained by Physicists

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"

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

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Peer Instruction

What is the most exciting future for computing?

a) Incremental improvements in computing architectures
b) Quantum computing
c) DNA computing
d) Biological Machines
e) Something completely different

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**