


# The Beauty and Joy of Computing

## Lecture #24 Future of Computing



UC Berkeley EECS  
Lecturer  
Gerald Friedland

**Amazon Prime Air!**

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




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






## Lecture Overview

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





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## Computer Technology - Growth!

<ul style="list-style-type: none"> <li><b>Processor</b> <ul style="list-style-type: none"> <li>Speed 2x / 2 years (since '71)</li> <li>100X performance last decade</li> <li>When you graduate: 3 GHz, 32 Cores</li> </ul> </li> <li><b>Memory (DRAM)</b> <ul style="list-style-type: none"> <li>Capacity: 2x / 2 years (since '96)</li> <li>64x size last decade.</li> <li>When you graduate: 128 GibiBytes</li> </ul> </li> <li><b>Disk</b> <ul style="list-style-type: none"> <li>Capacity: 2x / 1 year (since '97)</li> <li>250X size last decade.</li> <li>When you graduate: 16 TeraBytes</li> </ul> </li> </ul>	<p>Kilo (<math>10^3</math>) &amp; Kibi (<math>2^{10}</math>) ↓ Mega (<math>10^6</math>) &amp; Mebi (<math>2^{20}</math>) ↓ Giga (<math>10^9</math>) &amp; Gibi (<math>2^{30}</math>) ↓ Tera (<math>10^{12}</math>) &amp; Tebi (<math>2^{40}</math>) ↓ Peta (<math>10^{15}</math>) &amp; Pebi (<math>2^{50}</math>) ↓ Exa (<math>10^{18}</math>) &amp; Exbi (<math>2^{60}</math>) ↓ Zetta (<math>10^{21}</math>) &amp; Zebi (<math>2^{70}</math>) ↓ Yotta (<math>10^{24}</math>) &amp; Yobi (<math>2^{80}</math>)</p>
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## 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](http://www.makehellaofficial.blogspot.com)



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

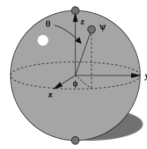
- Kid meets giant Texas people exercising zen-like yoga. – Rolf O
- Kind men give ten percent extra, zesfully, youthfully. – Hava E
- Kissing Mentors Gives Testy Persistent Extremists Zealous Youthfulness. – Gary M
- Kindness means giving, teaching, permeating excess zeal yourself. – Hava E
- Killing messengers gives terrible people exactly zero, yo
- Kindergarten means giving teachers perfect examples (a) 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)

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## 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](http://en.wikipedia.org/wiki/Quantum_computer)

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**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?


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**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  $\alpha$  to
  - $\sqrt{2^{72}} = 2^{36}$
  - $2^{36}$  checks needed / 720 Gchecks/sec/lab
  - = 0.1 sec/lab

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**Quantum Computing Explained by Physicists**



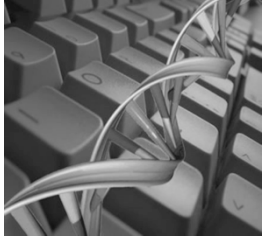
[www.phdcomics.com/tv](http://www.phdcomics.com/tv)

<http://www.youtube.com/watch?v=T2DXrs0OpHUs>

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**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](http://en.wikipedia.org/wiki/DNA_computing)





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[www.eecs.berkeley.edu/~maharbiz/Cyborg.html](http://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
  - Implanted 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?

- Incremental improvements in computing architectures
- Quantum computing
- DNA computing
- Biological Machines
- Something completely different

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## 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**

