## 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?**

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**

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## 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

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 ($2^{80}$)

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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

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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, 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
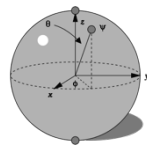- Kissing me gives ten percent extra zeal & youth! – Dan G (borrowing parts)

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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

## 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

`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`

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`www.technologyreview.com/article/412185/tr10-biological-machines/`

## 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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## 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**

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