



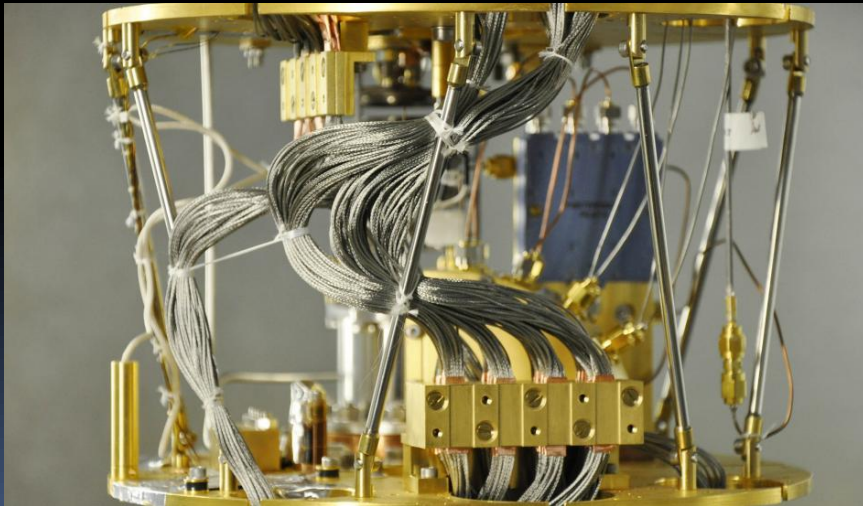
UC Berkeley
EECS Lecturer
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The Beauty and Joy of Computing

Lecture #23 Future of Computing



DATA OVERPOWERS COMPUTING



Too much energy consumption and slowing computational advances increases the demand for new processing advances such as quantum computers.

<http://www.newsweek.com/computers-need-be-more-human-brains-262504>

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, 16 Cores?

■ Memory (DRAM)

- Capacity: 2x / 2 years (since '96)
- 64x size last decade.
- When you graduate: 32 GibiBytes?

■ Disk

- Capacity: 2x / 1 year (since '97)
- 250X size last decade.
- When you graduate: 4 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})





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





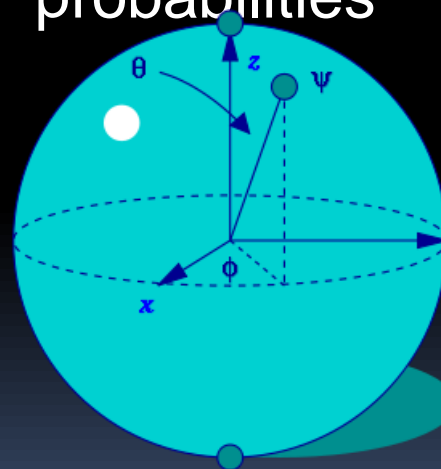
Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta

- 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 P****-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)
- Kadabra Must Give Tough Pokemon Extra Zen, Youch! – Pierce V



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?

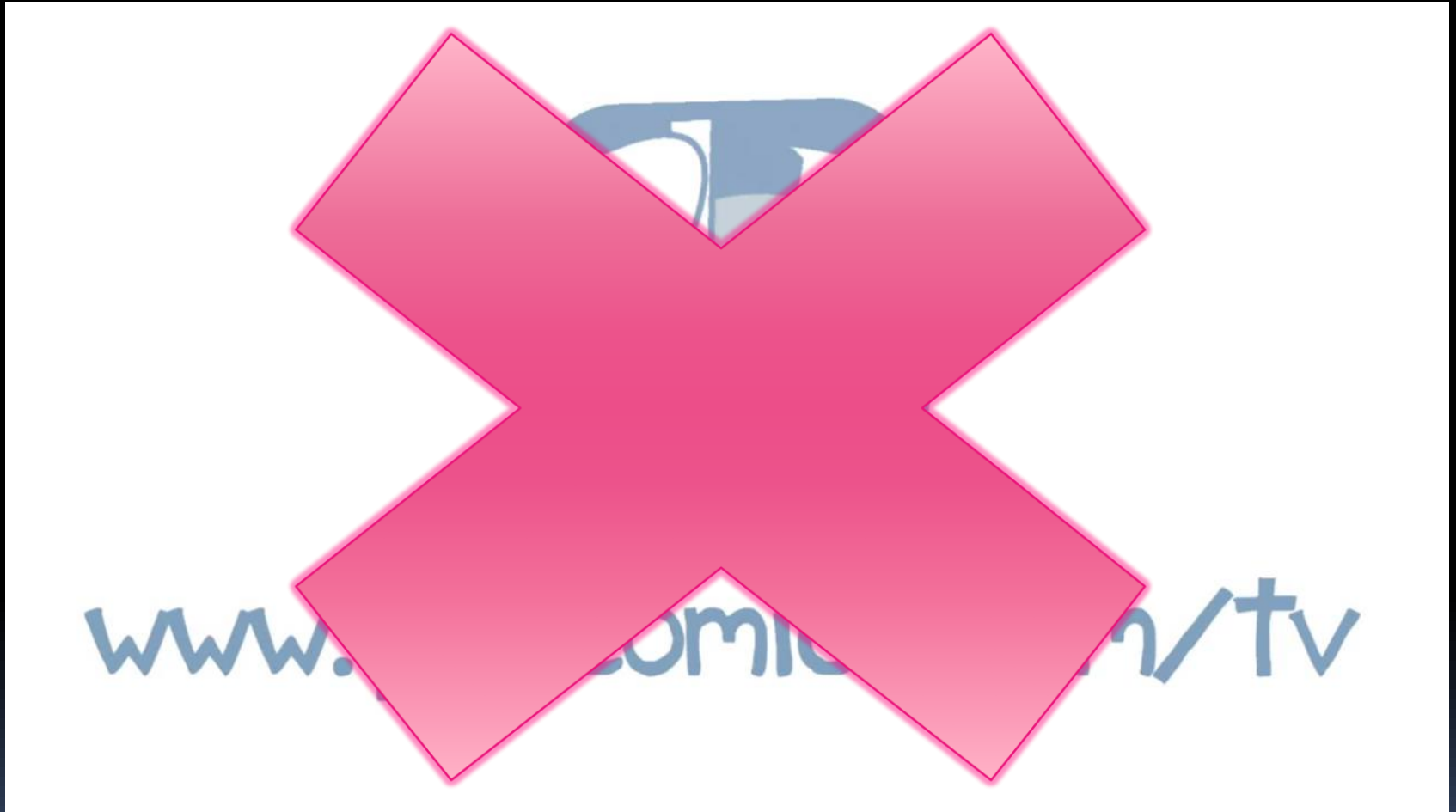


Quantum Computing (3)

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



Quantum Computing Explained by Physicists



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

https://www.youtube.com/watch?v=g_IaVepNDT4

UC Berkeley "The Beauty and Joy of Computing" : **Future of Computing** (9)

Garcia + Vollucci



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

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





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

