



The Beauty and Joy of Computing

Lecture #21 Future of Computing



Internet Balloons

From TechCrunch: Today, Sri Lanka announced that it's the first country to ever get universal Internet access from Google's Project Loon. Thanks to a partnership with Google, the country promises "affordable high-speed Internet" for all of its residents.



<http://techcrunch.com/2015/07/29/not-so-loony-now-is-it/>



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Lecture Overview

- Where will today's computers go?
- Quantum Computing
- Biological Computing & Interfaces



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II

Where will today's computers go?

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: 16 TeraBytes

Kilo (10³) & Kibi (2¹⁰)
 ↓
 Mega (10⁶) & Mebi (2²⁰)
 ↓
 Giga (10⁹) & Gibi (2³⁰)
 ↓
 Tera (10¹²) & Tebi (2⁴⁰)
 ↓
 Peta (10¹⁵) & Pebi (2⁵⁰)
 ↓
 Exa (10¹⁸) & Exbi (2⁶⁰)
 ↓
 Zetta (10²¹) & Zebi (2⁷⁰)
 ↓
 Yotta (10²⁴) & Yobi (2⁸⁰)



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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 giraffes 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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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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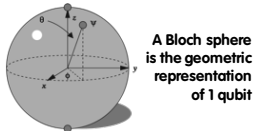
II

Quantum Computing

Quantum Computing (1/3)

en.wikipedia.org/wiki/Quantum_computer

- 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



en.wikipedia.org/wiki/Quantum_computer



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Quantum Computing (2/3)

- 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 (3/3)

- Say the password is exactly 72 bits (0/1)
- That's 2^{72} possibilities
 - 10 char password $\sim 2^{60}$
- 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
 - $\sqrt{2^{72}} = 2^{36}$
 - = 2^{36} checks needed / 720 Gchecks/sec/lab
 - = 0.1 sec/lab



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NSA seeks to build Quantum computer

www.washingtonpost.com/world/national-security/nsa-seeks-to-build-quantum-computer-that-could-crack-most-types-of-encryption/2014/01/02/REF279e-7195-11e3-8def-a3001140802_story.html

- Washington Post, 2014-01-03: "The U.S. National Security Agency (NSA) is trying to develop a quantum computer that could be used to crack almost any type of encryption currently in use, according to documents released by former NSA contractor Edward Snowden."
- "Once completed, the computer could be used to crack almost every type of encryption used to protect state secrets and other sensitive information, such as 1,024-bit RSA encryption keys, which would take hundreds of standard computers working together about 2,000 years to crack."



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Quantum Computing Explained by Physicists

www.youtube.com/watch?v=T2DXrs0OpHUs



www.phdcomics.com/tv



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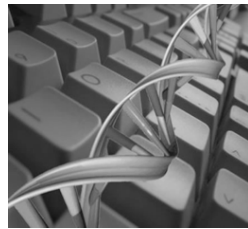
II

Biological Computing & Interfaces

DNA Computing

en.wikipedia.org/wiki/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
- Papers in "Nature"
 - In 2004, researchers claimed they built DNA Computer!
 - In 2013, researchers stored (and retrieved!) data on DNA (All Shakespeare's sonnets and audio clip of "I have a dream")



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Biological Machines

www.technologyreview.com/article/412185/tr10-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 will probably help get you there!
- We probably can't even imagine future software + hardware breakthroughs



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