



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/>



Admin Notes

- Schedule (see website)
- Explore Post Due Tomorrow
 - Comments Monday!
 - Must have 3, but comment more 😊
- Final Projects –
 - Be Creative and ambitious





Lecture Overview

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



**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 (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})



Ball





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)





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



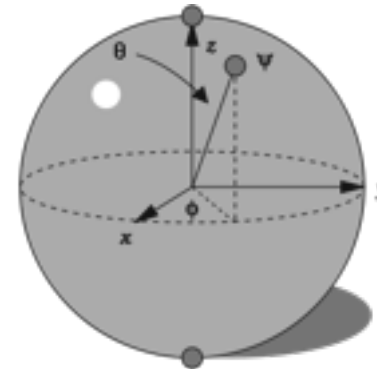


Quantum Computing



Quantum Computing (1/3)

- 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 (2/3)

- 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?





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 to**

$$\sqrt{2^{72}} = 2^{36}$$

- 2^{36} checks needed / 720 Gchecks/sec/lab
- ≈ 0.1 sec/lab

bjc

NSA seeks to build Quantum computer

- **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."*



bjc

www.youtube.com/watch?v=T2DXrs0OpHUs

Quantum Computing Explained by Physicists



www.phdcomics.com/tv



UC Berkeley "The Beauty and Joy of Computing": Future of Computing (13)



Ball

Biological Computing & Interfaces



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")





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
 - Implanted as Pupa
- Vision
 - Imagine devices that can collect, manipulate, store and act on info from environment



UC Berkeley "The Beauty and Joy of Computing": Future of Computing (16)





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 will probably help get you there!
- We probably can't even imagine future software + hardware breakthroughs

