The Beauty and Joy of Computing

Lecture #24
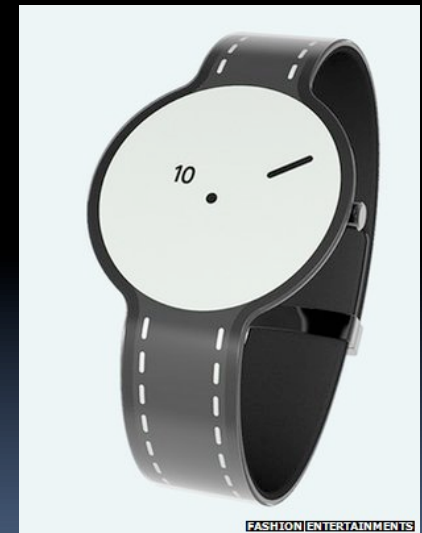## Future of Computing
and YOUR Future

UC Berkeley EECS
Lecturer
Gerald Friedland

Sony makes experimental e-paper watch

Message: Tech industry goes fashion!

http://www.bbc.com/news/technology-30245296

Administrivia: Become active!

- **With-Snap! Exam details**
  - No exam handed out unless you've filled in both HKN + our survey
  - No "study sheets" needed / allowed since you have access to Snap!

- **Final Exam details**
  - Only bring pen{,cil}s, three 8.5"x11" handwritten sheets (writing on both sides).
  - Leave backpacks, books, calculators, cells & pagers home!
  - Everyone must take ALL of the final!
  - Bring your "Beauty and Joy of Computing" Art/Poem for extra credit!

- **If you did well in CS10 and want to be on staff?**
  - Usual path: **Lab Assistant** 🖐 **Reader** 🖐 **TA**
  - Indicate on your final survey whether you're even remotely interested
  - We strongly encourage anyone who gets an B or above in the class to follow this path...

Opportunities Next Semester

- **CS61A (1ˢᵗ course in CS major)**
  - Structure and Interpretation of Computer Programs, Python
- **CS9 series (learn a second language)**
  - I would recommend Python next, CS9H
- **GamesCrafters DeCal (Game Theory R & D)**
  - Develop SW, analysis on 2-person games of no chance. (e.g., go, chess, connect-4, nim, etc.)
  - Req: Game Theory / SW Interest
- **MS-DOS X DeCal (Mac Student Developers)**
  - Learn to program Macintoshes.
  - Req: Interest. Owning a mac helps, not required.
- **UCBUGG DeCal (Recreational Graphics)**
  - Develop computer-generated images, animations.
  - Req: 3D interest

Ok, I'm hooked! Where do I go next?

- **CS Major / Minor**
  - You are here

- **CS61A**
  - In Python, one big idea every week. Awesome!

- **CS61B**
  - In Java, data structures, algorithms and software engineering (lite)

- **CS61C**
  - In C and MIPS, Great ideas in computer architecture (parallelism) … I teach this!

CS10

CS61A

CS61B

CS61C

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Things to remember from CS10

- **Abstraction**
  - The key idea underpinning all computer science
  - …and (in CS10) functions, HOFs
- **…From Blown to Bits**
  - Technology has social implications (privacy, energy, copyright, etc); try to see the big picture
  - It also often has unintended consequences!
  - Things are never black or white, pure good or pure evil
- **…From "Program or Be Programmed"**
  - Technology has an explicit and implicit agenda, understanding it is important.
  - Learning to program is empowering (Steve Jobs' video)

Exciting Future Implications

- **In computing, chronic unsolved problem**
  - Easy parallel programming
- **Implications for apps:**
  - HUGE Computing power available in cell phone, car
    - On-body health monitoring
    - Google + library of congress
- **As devices shrink…**
  - The need for great HCI (human-computer interfaces) critical as ever! (voice, gesture)

- **Natural language processing?**
- **Interact by motion!**
- **3D displays?**
- **Personal Robotics?**
- **Self-driving cars?**
- **3D Printing?**
- **Optical/quantum computing?**
- **Personal air vehicle?**
- **Space travel?**
- **Computer displays in glasses?**
- **Flexible displays?**
- **Smart drones?**
- **Energy!**

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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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 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**
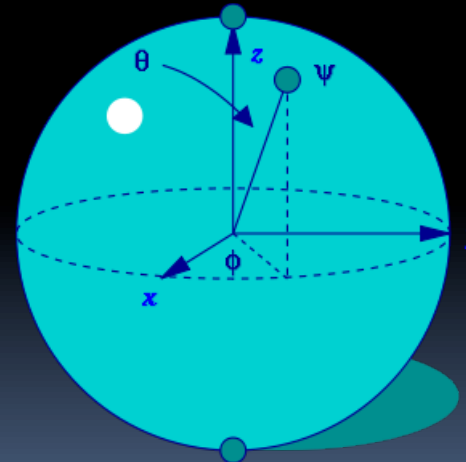
A Bloch sphere is the geometric representation of 1 qubit

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?**

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 <u>years</u>/lab

- **72-qubit quantum computers in time α to $\sqrt{2^{72}} = 2^{36}$**

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

  ≈ 0.1 <u>sec</u>/lab

www.phdcomics.com/tv
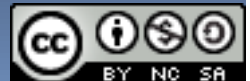
DNA Computing

- **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
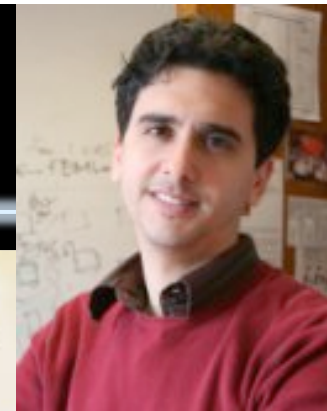- **In 2004, researchers claimed they built one**
  - Paper in "Nature"

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

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**

The Future for Future Cal Alumni

- **What's The Future?**

- **New Millennium**
  - Always-on internet connectivity + internet of things!
  - AI breakthroughs
  - HCI breakthroughs
  - Post-PC Era (power is in cloud, interface in pocket)

"The best way to predict the future is to invent it"
– Alan Kay

The Future is up to you!

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