Evidence has emerged that the brain's capacity to absorb information is limiting the amount of data humanity can produce.

EPA for CS61C Surveys (see Piazza)

Register your iclickers!

www.technologyreview.com/blog/arxiv/27379/
6 Great Ideas in Computer Architecture

1. Abstraction
   ( Layers of Representation/Interpretation)
2. Moore’s Law
3. Principle of Locality/Memory Hierarchy
4. Parallelism
5. Performance Measurement & Improvement
6. Dependability via Redundancy
We learned Old-School “Machine Structures”

Coordination of many levels (layers) of abstraction
Software

- Parallel Requests
  Assigned to computer
  e.g., Search “CS61C”

- Parallel Threads
  Assigned to core
  e.g., Lookup, Ads

- Parallel Instructions
  >1 instruction @ one time
  e.g., 5 pipelined instructions

- Parallel Data
  >1 data item @ one time
  e.g., Add of 4 pairs of words

- Hardware descriptions
  All gates functioning in parallel at same time

Hardware

- Warehouse Scale Computer

Harness Parallelism & Achieve High Performance

Logic Gates

Computer

Main Memory

Input/Output

Functional Unit(s)

Instruction Unit(s)

A_0 + B_0 A_1 + B_1 A_2 + B_2 A_3 + B_3

A_0 + B_0 A_1 + B_1 A_2 + B_2 A_3 + B_3

(Lines)

A0

A1

A2

A3

B0

B1

B2

B3

Project 1

Project 2

Project 3

Project 4
We made HW/SW contact!

High Level Language Program (e.g., C)  
Compiler

Assembly Language Program (e.g., MIPS)  
Assembler

Machine Language Program (MIPS)

Machine Interpretation

Hardware Architecture Description (e.g., block diagrams)  
Architecture Implementation

Logic Circuit Description (Circuit Schematic Diagrams)

```
tag = v[k];
v[k] = v[k+1];
v[k+1] = temp;
```

```
lw $t0, 0($2)  
lw $t1, 4($2)  
sw $t1, 0($2)  
sw $t0, 4($2)
```

0000 1001 1100 0110 1010 1111 0101 1000  
1010 1111 0101 1000 0000 1001 1100 0110  
1100 0110 1010 1111 0101 1000 0000 1001  
0101 1000 0000 1001 1100 0110 1010 1111
<table>
<thead>
<tr>
<th>Week #</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>#14</td>
<td>Last week o’ classes</td>
<td>I/O Disks</td>
<td>VM + I/O</td>
<td>GPU Coding</td>
<td>Open Lab</td>
</tr>
<tr>
<td>#15</td>
<td>RRR Week</td>
<td></td>
<td></td>
<td></td>
<td>Today Summary</td>
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<tr>
<td>#16</td>
<td>Finals Week</td>
<td>Final Exam 3-6pm in 2050 VLSB</td>
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<td>Review TBA</td>
<td></td>
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</tr>
</tbody>
</table>
Administrivia: Become active!

- **Final Exam details**
  - Only bring pens, two 8.5”x11” handwritten sheets (writing on both sides) + green sheet.
  - Leave backpacks, books, calculators home!
  - Everyone must take ALL of the final!

- **If you did well in CS3 or 61[ABC] (B or above) and want to be on staff?**
  - Usual path: Lab Assistant → Reader → TA
  - LA: sign up w/Jenny Jones (jennyj@eecs) before 1st week
  - Reader/TA forms: [www.cs/~juliea/](http://www.cs/~juliea/)
  - I strongly encourage anyone who gets an B or above in the class to follow this path…
Taking advantage of Cal Opportunities

“The Godfather answers all of life’s questions”
- Heard in “You’ve got Mail”

- Why were we the #2 Univ in the WORLD?
  - Research, research, research!
  - Whether you want to go to grad school or industry, you need someone to vouch for you!
    - ...as is the case with the Mob

- Techniques
  - Find out what you like, do lots of web research (read published papers), hit OH of Prof, show enthusiasm & initiative

- http://research.berkeley.edu/
- http://researchmatch.herokuapp.com/
Dan’s Research Projects

- **CS Illustrated**
  
  ![CS Illustrated Example](image)

- **Ensemble**
  
  ![Ensemble Example](image)

- **Improve CS10/Snap!**
  
  ![Improve CS10/Snap! Example](image)

- **Improve codepath**
Opportunities Fall 2013

- **CS150** (Digital Systems Design Techniques)
  - If you liked SDS, this is a great follow-on course!

- **CS9 Series** (Learn another computer language)
  - I recommend Python (CS9H), Unix (CS9E), C++ (CS9F)

- **GamesCrafters** (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** (Mac Student Developers)
  - Learn to program Macintoshes.
  - Req: Interest. Owning a mac helps, not required.
  - Taught as a DeCal by MS-DOS X veterans

- **UCBUGG** (Recreational Graphics)
  - Develop computer-generated images, animations.
  - Req: 3D interest
  - Taught as a DeCal by UCBUGG veterans
Review: 5 components of any Computer

In the future, what'll be the most important computer component?

Computer

- Processor
  - Control ("brain")
  - Datapath ("brawn")
- Memory
- Devices
  - Input
  - Output

a) Control
b) Datapath
c) Memory
d) Input
e) Output
“Forget cloning. Forget TVs on your wrist watch. The biggest invention of the next 100 years will be the ability to directly connect your brain to a machine, aka wet computing.” – Dan Garcia

- A macaque monkey at Duke University can already control a robotic arm with thought.
- DARPA interested for mind-control robots & flying
- Virtual Reality achieved with proper I/O interfacing…
Penultimate slide: Thanks to the staff!

- **TAs**
  - Head TA Justin Hsia
  - Paul Ruan
  - Alan Christopher
  - Sagar Karandikar
  - Sung Roa Yoon
  - Zachary Bush

- **Readers**
  - Anirudh Garg
  - Joyjit Daw
  - Kevin Lee
  - Stephen Chen

Thanks to all the former CS61C instructors who have added to these notes…
The Future for Future Cal Alumni

- What’s The Future?
- New Millennium
  - Ubiquitous & Quantum Computing, Nanotechnology, 10 M "volunteer" CPUs, the Parallel revolution...
  - Rapid Changes in Technology, Post-PC Era!
  - World’s 2nd Best Education
  - Never Give Up!

“The best way to predict the future is to invent it”
- Alan Kay

The Future is up to you!