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UCB CS61C

Great Ideas in Computer Architecture (aka Machine Structures)

Register your iclickers!

Lecture 40 – Summary & Goodbye

TOP 10 BREAKTHROUGH TECHNOLOGIES (MIT TR)



Agricultural Drones

Relatively cheap drones with advanced sensors and imaging capabilities are giving farmers new ways to increase yields and reduce crop damage.



Ultraprivate Smartphones

New models built with security and privacy in mind reflect the Zeitgeist of the Snowden era.



Brain Mapping

A new map, a decade in the works, shows structures of the brain in far greater detail than ever before, providing neuroscientists with a guide to its immense complexity.



Neuromorphic Chips

Microprocessors configured more like brains than traditional chips could soon make computers far more astute about what's going on around them.



Genome Editing

The ability to create primates with intentional mutations could provide powerful new ways to study complex and genetically baffling brain disorders.



Microscale 3-D Printing

Inks made from different types of materials, precisely applied, are greatly expanding the kinds of things that can be printed.



Mobile Collaboration

The smartphone era is finally getting the productivity software it needs.



Oculus Rift

Thirty years after virtual-reality goggles and immersive virtual worlds made their debut, the technology finally seems poised for widespread use.



Agile Robots

Computer scientists have created machines that have the balance and agility to walk and run across rough and uneven terrain, making them far more useful in navigating human environments.



Smart Wind and Solar Power

Big data and artificial intelligence are producing ultra-accurate forecasts that will make it feasible to integrate much more renewable energy into the grid.

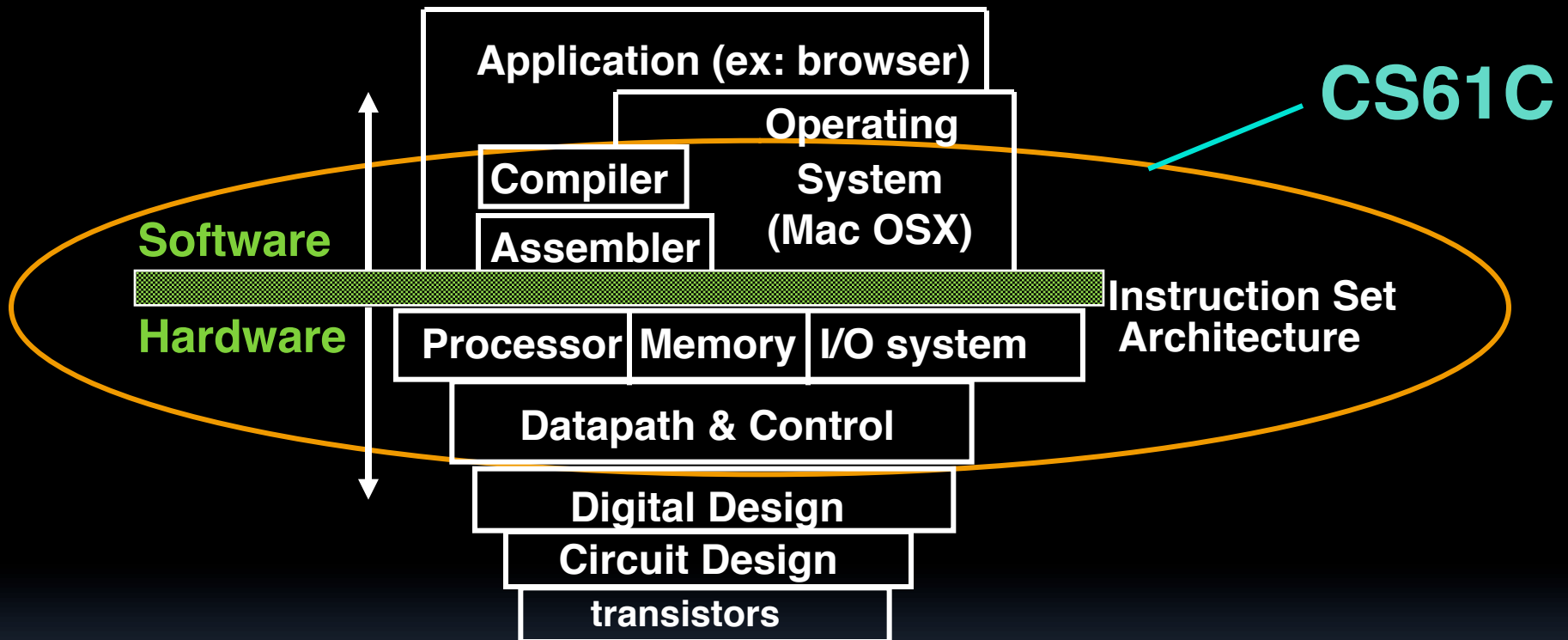
www.technologyreview.com/lists/technologies/2014/

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*



...and New-School Machine Structures

(It's a bit more complicated!)

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

*Harness
Parallelism &
Achieve High
Performance*

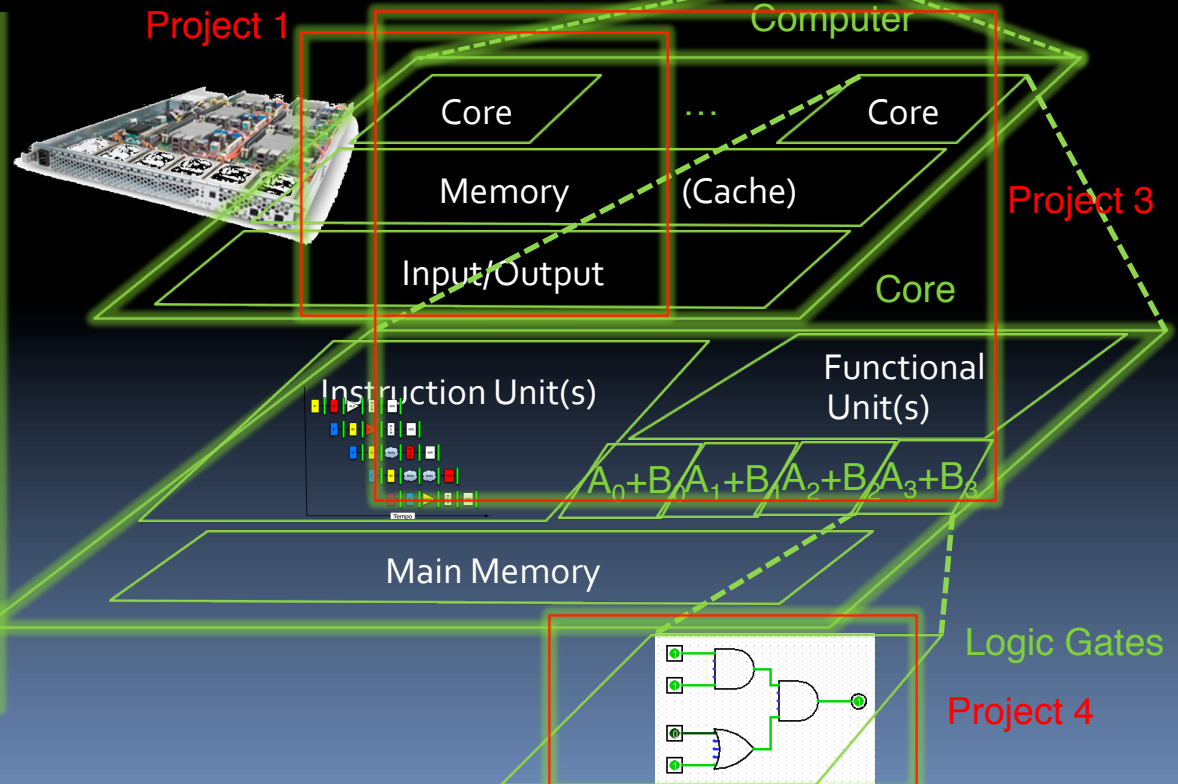
Hardware

Warehouse
Scale
Computer



Project 2

Smart
Phone



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)

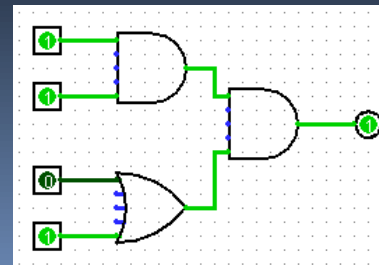
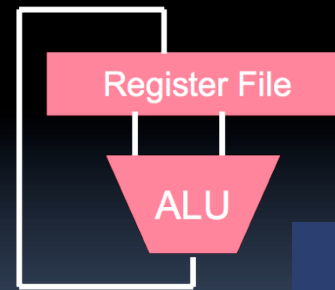
Architecture Implementation

Logic Circuit Description (Circuit Schematic Diagrams)

```
temp = 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
```



Upcoming Calendar

Week #	Mon	Tue	Wed	Thu	Fri
#14 Last week o' classes	I/O Disks	VM + I/O	GPU Coding	Open Lab	Today Summary
#15 RRR Week			Review 12-3pm 155 Dwinelle		
#16 Finals Week		Final Exam 11:30-2:30pm 1 Pimentel			



Administrivia: Become active!

- **Final Exam details**

- Only bring pen{,cil}s, 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 CS10 or 61[ABC] (B or above) and want to be on staff?**

- Usual path: Lab Assistant \Rightarrow Reader \Rightarrow TA
- Reader/TA/LA forms:
www.eecs.berkeley.edu/Scheduling/ta_applications.shtml
- 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"

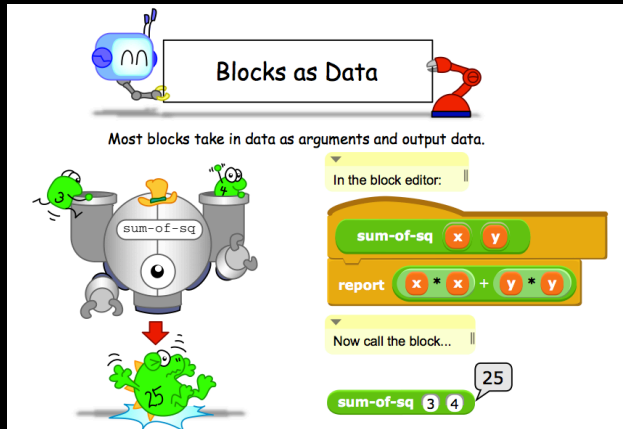
– Heard in "You've got Mail"

- **Why are we one of the top Univ in the WORLD?**
 - Research, reseach, 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, be a go-getter!
- <http://research.berkeley.edu/>
- <http://researchmatch.heroku.com/>

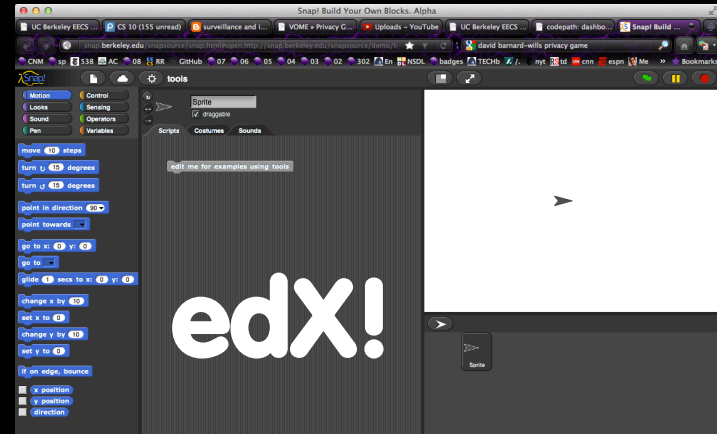


Dan's Research Projects

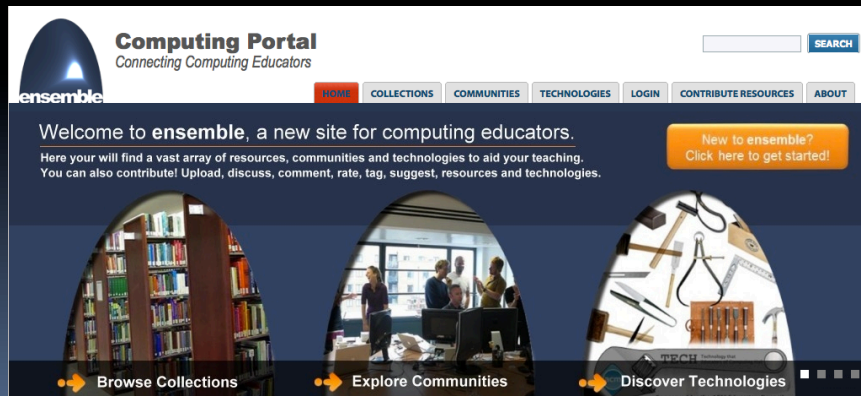
- CS Illustrated



- Improve CS10/Snap!



- Ensemble



- Game Theory!

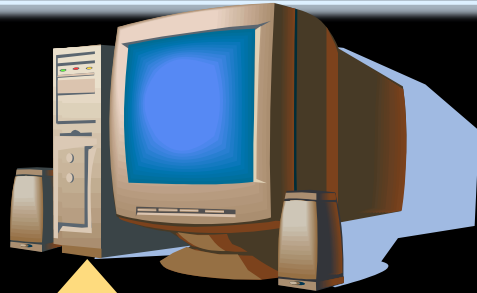


Opportunities Next Semester

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



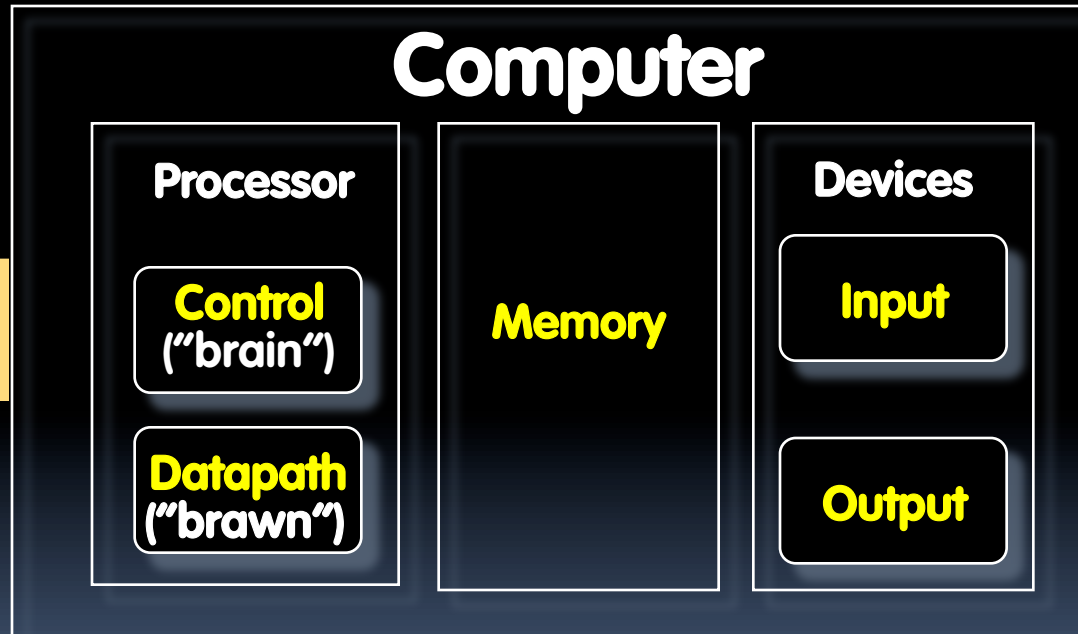
Review: 5 components of any Computer



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



- a) Control
- b) Datapath
- c) Memory
- d) Input
- e) Output



Peer Instruction Opinion



- “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...



Jose Carmena, UCB EECS Prof
Research: Brain-Machine Interface
www.eecs.berkeley.edu/~carmena/



Penultimate slide: Thanks to the staff!

▪ TAs

- Head TA Alan Christopher
- Jeffrey Dong
- Kevin Liston
- Roger Chen
- Sagar Karandikar
- Shreyas Chand
- Sung Roa Yoon
- William Ku

▪ Readers

- William Huang
- Ryoko Janlie
- Neal Lawton
- Jerry Lung
- Matthew Griffin

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!
 - Arguably World's Best Education
 - Never Give Up!

"The best way to predict the future is to invent it"

– Alan Kay

The Future is up to you!

