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`inst.eecs.berkeley.edu/~cs61c`
UCB CS61C
Great Ideas in Computer Architecture
(aka Machine Structures)

Lecture 39 –
Summary & Goodbye

CNN: 'GANGNAM STYLE' BREAKS YOUTUBE

"Gangnam Style," the South Korean pop star's enduring video phenomenon from 2012, has surpassed 2,147,483,647 views on YouTube, maxing out the site's original view counter.

"We never thought a video would be watched in numbers greater than a 32-bit integer (=2,147,483,647 views), but that was before we met PSY," wrote Google, which owns YouTube, in a blog post this week. " 'Gangnam Style' has been viewed so many times we have to upgrade!"



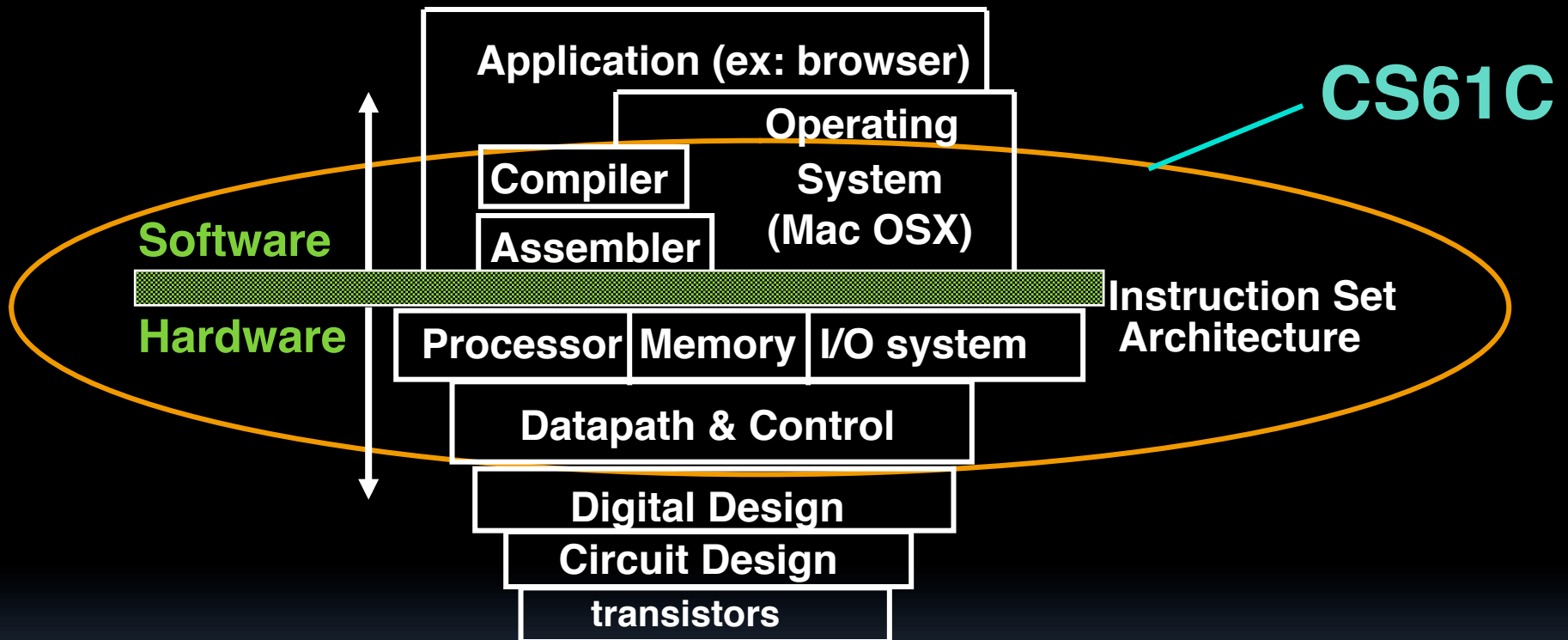
www.cnn.com/2014/12/03/showbiz/gangnam-style-youtube/

Six 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*

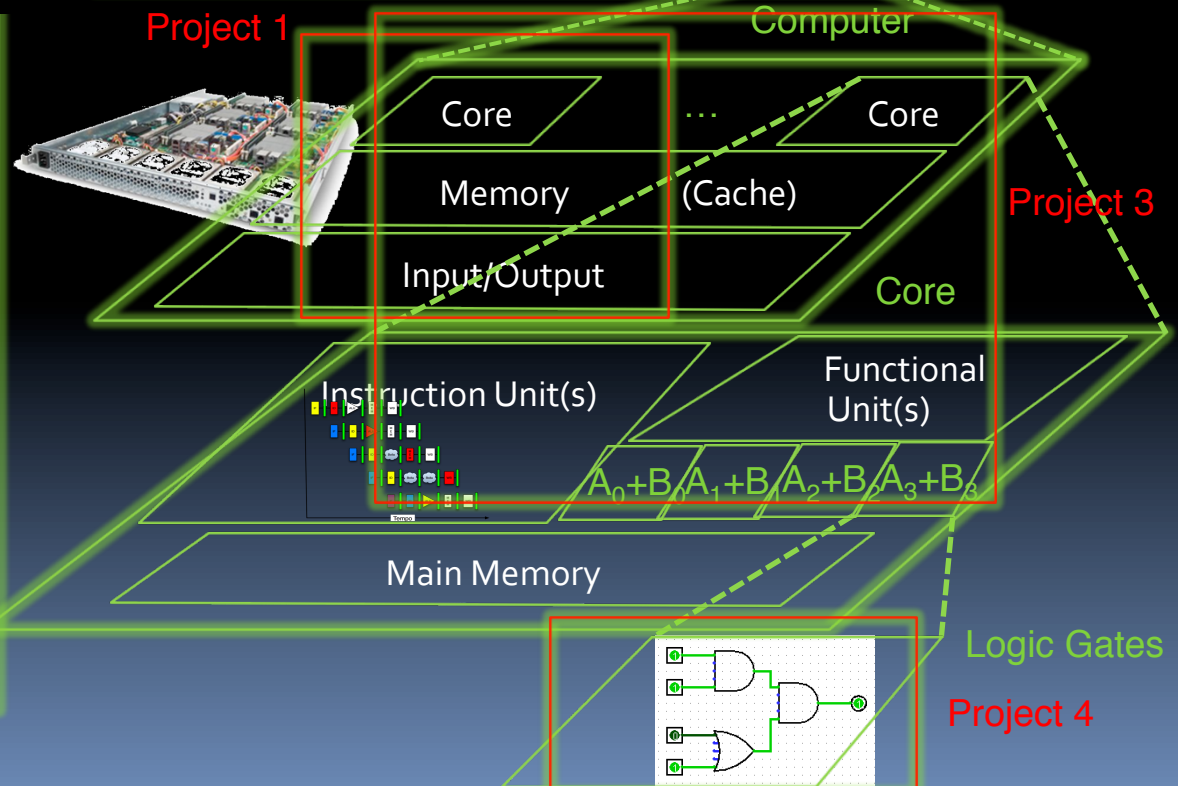
Hardware

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)

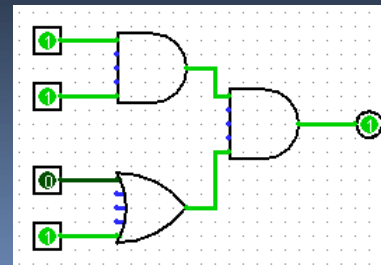
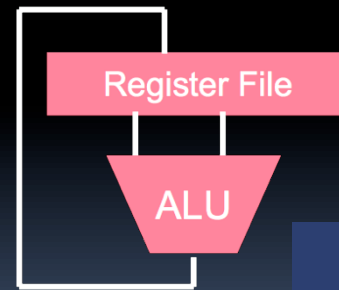
Architecture Implementation

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		I/O Networks		Today Summary
#15 RRR Week	Review 12-3pm 155 Dwinelle				
#16 Finals Week		Final Exam 7-10pm Here! (Wheeler Aud)			



Administrivia: Become active!

- **Final Exam details**

- Only bring pens, three 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"

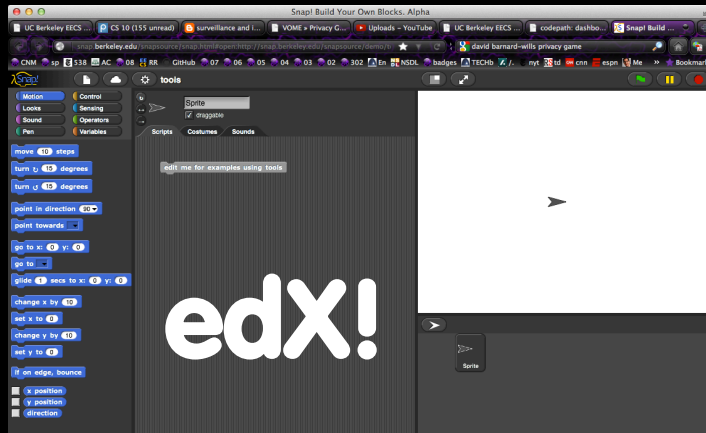
– Heard in "You've got Mail"

- **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/>



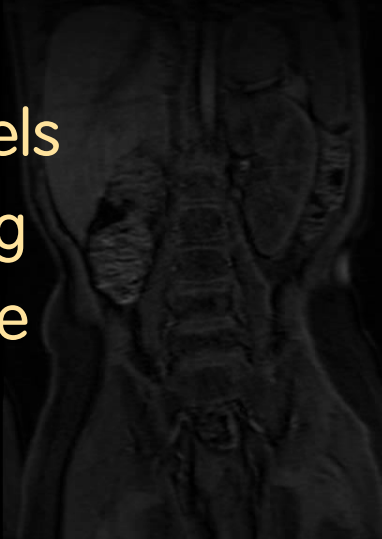
Dan's Research Projects

- Improve CS10/Snap!
- Game Theory!



Miki's Research (Medical Imaging)

- **Imaging – Signal processing**
 - Signal models
 - Fast imaging
 - Compressive sampling
- **Efficient Computation**
 - Compressive computation
 - Parallel computing
 - Efficient algorithms



- **Hardware**
 - Flexible MRI coils



Opportunities Next Semester

- **CS150 (Digital Systems Design Techniques)**
 - If you liked SDS, this is a great follow-on course!
- **CS162 (OS and System Programming)**
 - If you liked the rest, this is a great follow-on course!
- **CS9 series (learn a second language)**
 - I would recommend Unix & Python next, CS9E & 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

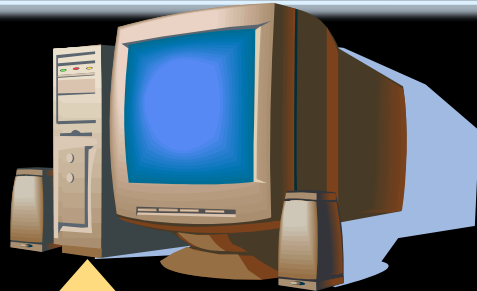


Opportunities Next Semester

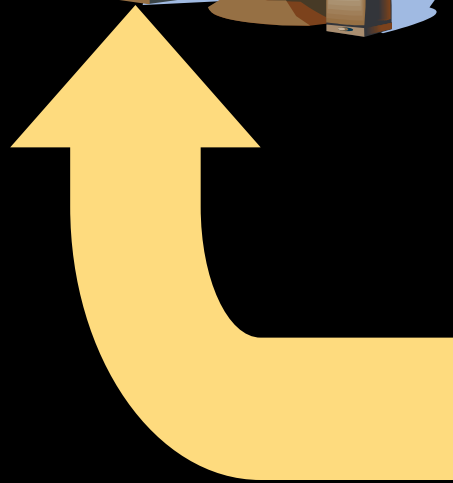
- **EE20 EE12X** (signals, systems, comm, networks and optimization)
 - If you like making the computer solve interesting problems and make things work!
- **EE40 EE105, 14X series** (Circuits)
 - If you like to know what's below the gates
- **EE13X** (Devices)
 - If you want to know how to make IC and devices for computing



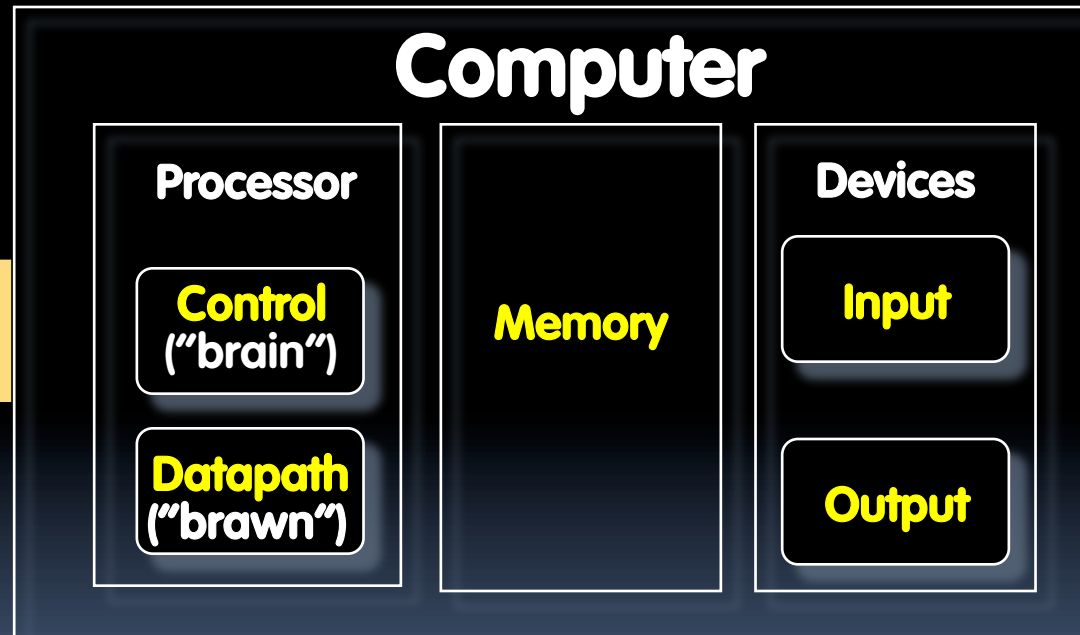
Review: 5 components of any Computer



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 Sagar Karandikar
- Head TA Jeffrey Dong
- David Adams
- Shreyas Chand
- Roger Chen
- Rohan Chitnis
- Alex Chou
- Riyaz Faizullabhoy
- Matt Griffin
- Fred Hong
- William Huang
- Kevin Liston
- Andrew Luo
- Jay Patel

▪ Readers

- Dasheng Chen
- Xinghua Duo
- Jonathan Eng
- Christopher Hsu
- Ryoko Janlie
- Nolan Lum
- Harrison Wang

**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, The Internet of Things, **the Parallel revolution...**
 - Rapid Changes in Technology, Post-PC Era!
 - 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!

