inst.eecs.berkeley.edu/~cs61c

CS61C : Machine Structures

Lecture #1 – Introduction

2007-01-17

There are two handouts today at the front and middle of the room!

Lecturer SOE Dan Garcia

www.cs.berkeley.edu/~ddgarcia

Time Lapse! ⇒

In the next 4 yrs, time-lapse movies will show the construction of the new CITRIS building. High Def!!

www.cs.berkeley.edu/~ddgarcia/tl/

"I stand on the shoulders of giants…"

Prof David Patterson

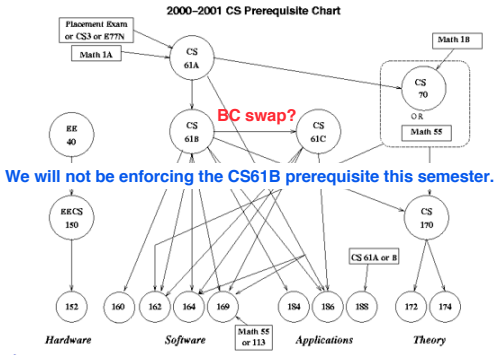
Prof John Wawrznek

TA Andy Carle

TA Kurt Meinz

Thanks to these talented folks (& many others) whose contributions have helped make 61C a really tremendous course!

Where does CS61C fit in?



http://hkn.eecs.berkeley.edu/student/cs-prereq-chart1.gif

Are Computers Smart?

- To a programmer:
  - Very complex operations / functions:
    - `(map (lambda (x) (* x x)) '(1 2 3 4))`
  - Automatic memory management:
    - `List l = new List;`
  - "Basic" structures:
    - Integers, floats, characters, plus, minus, print commands

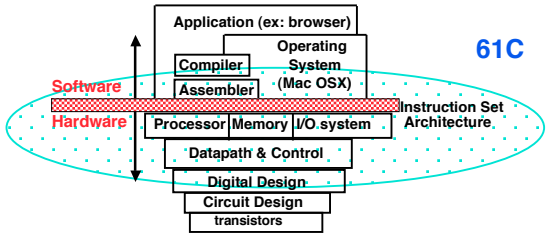
Computers are smart!

Are Computers Smart?

- In real life:
  - Only a handful of operations:
    - {and, or, not}
  - No automatic memory management.
  - Only 2 values:
    - {0, 1} or {low, high} or {off, on}

Computers are dumb!

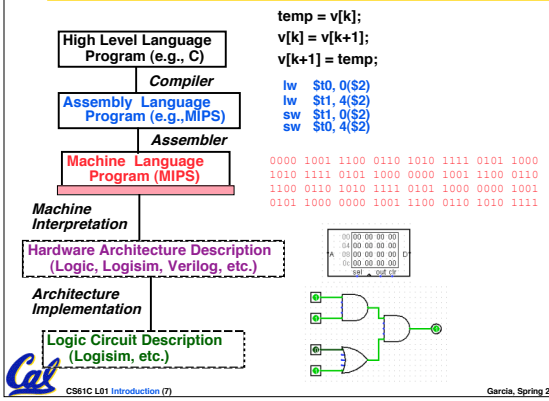
What are "Machine Structures"?



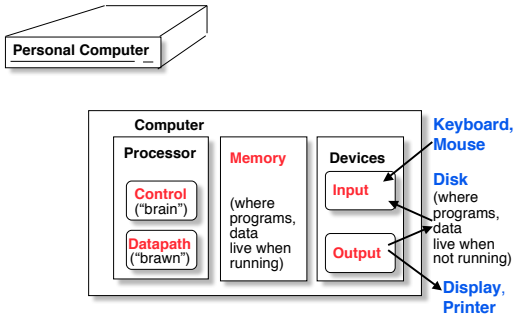
* Coordination of many

levels (layers) of abstraction

61C Levels of Representation



Anatomy: 5 components of any Computer



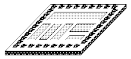
Overview of Physical Implementations

The hardware out of which we make systems.

- Integrated Circuits (ICs)
  - Combinational logic circuits, memory elements, analog interfaces.
- Printed Circuits (PC) boards
  - substrate for ICs and interconnection, distribution of CLK, Vdd, and GND signals, heat dissipation.
- Power Supplies
  - Converts line AC voltage to regulated DC low voltage levels.
- Chassis (rack, card case, ...)
  - holds boards, power supply, provides physical interface to user or other systems.
- Connectors and Cables.

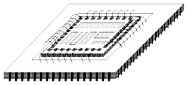
Integrated Circuits (2007 state-of-the-art)

Bare Die



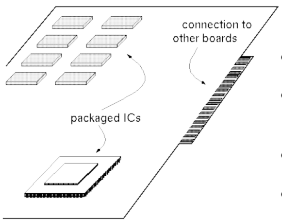
- Primarily Crystalline Silicon
- 1mm - 25mm on a side
- 2007 feature size ~ 65 nm = 65 x 10^{-9}m (then 45, 32, 22, and 16 [by yr 2013])
- 100 - 1000M transistors
- (25 - 100M "logic gates")
- 3 - 10 conductive layers
- "CMOS" (complementary metal oxide semiconductor) - most common.

Chip in Package



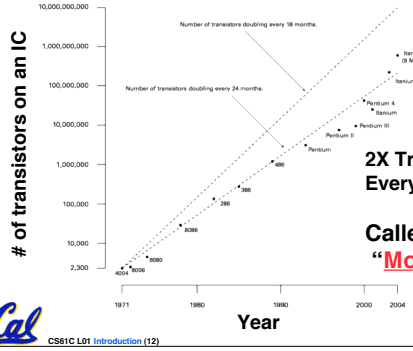
- Package provides:
  - spreading of chip-level signal paths to board-level
  - heat dissipation.
- Ceramic or plastic with gold wires.

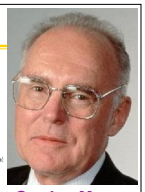
Printed Circuit Boards



- fiberglass or ceramic
- 1-20 conductive layers
- 1-20 in on a side
- IC packages are soldered down.
- Provides:
  - Mechanical support
  - Distribution of power and heat.

Technology Trends: Microprocessor Complexity



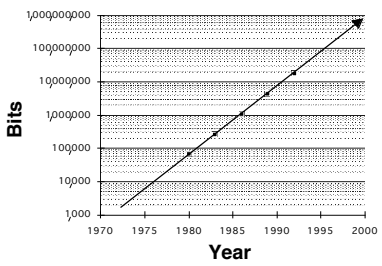


Gordon Moore
Intel Cofounder
B.S. Cal 1950!

2X Transistors / Chip Every 1.5 years

Called "Moore's Law"

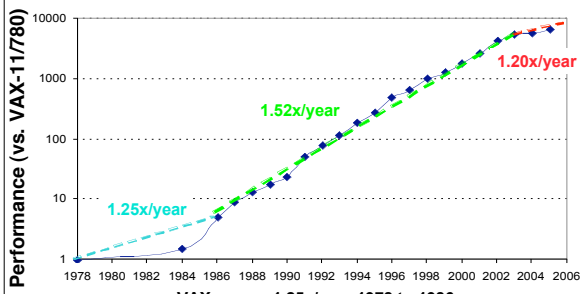
Technology Trends: Memory Capacity (Single-Chip DRAM)



year	size (Mbit)
1980	0.0625
1983	0.25
1986	1
1989	4
1992	16
1996	64
1998	128
2000	256
2002	512
2004	1024 (1Gbit)

- Now 1.4X/yr, or 2X every 2 years.
- 8000X since 1980!

Technology Trends: Uniprocessor Performance (SPECint)



- VAX : 1.25x/year 1978 to 1986
- RISC + x86: 1.52x/year 1986 to 2002
- RISC + x86: 1.20x/year 2002 to present

Computer Technology - Dramatic Change!

- **Memory**
  - DRAM capacity: 2x / 2 years (since '96); 64x size improvement in last decade.
- **Processor**
  - Speed 2x / 1.5 years (since '85); [slowing!] 100X performance in last decade.
- **Disk**
  - Capacity: 2x / 1 year (since '97) 250X size in last decade.

Computer Technology - Dramatic Change!

We'll see that Kilo, Mega, etc. are incorrect later!

- **State-of-the-art PC when you graduate: (at least…)**
  - Processor clock speed: 5000 MegaHertz (5.0 GigaHertz)
  - Memory capacity: 8000 MegaBytes (8.0 GigaBytes)
  - Disk capacity: 2000 GigaBytes (2.0 TeraBytes)
  - New units! Mega ⇒ Giga, Giga ⇒ Tera

(Tera ⇒ Peta, Peta ⇒ Exa, Exa ⇒ Zetta Zetta ⇒ Yotta = 10^{24})

CS61C: So what's in it for me?

- **Learn some of the big ideas in CS & engineering:**
  - Principle of abstraction, used to build systems as layers
  - 5 Classic components of a Computer
  - Data can be anything (integers, floating point, characters): a program determines what it is
  - Stored program concept: instructions just data
  - Principle of Locality, exploited via a memory hierarchy (cache)
  - Greater performance by exploiting parallelism
  - Compilation v. interpretation thru system layers
  - Principles/Pitfalls of Performance Measurement

Others Skills learned in 61C

- **Learning C**
  - If you know one, you should be able to learn another programming language largely on your own
  - Given that you know C++ or Java, should be easy to pick up their ancestor, C
- **Assembly Language Programming**
  - This is a skill you will pick up, as a side effect of understanding the Big Ideas
- **Hardware design**
  - We'll learn just the basics of hardware design
  - CS 150, 152 teach this in more detail

Course Lecture Outline

- Number representations
- C-Language (basics + pointers)
- Storage management
- Assembly Programming
- Floating Point
- `make`-ing an Executable (compilation, assembly)
- Logic Circuit Design
- CPU organization
- Pipelining
- Caches
- Virtual Memory
- Performance
- I/O Interrupts
- Disks, Networks
- Advanced Topics

Yoda says…

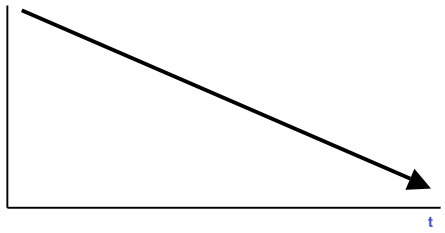
"Always in motion is the future…"

Our schedule may change slightly depending on some factors. This includes lectures, assignments & labs…

Texts

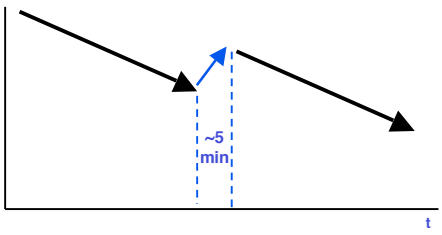
- Required: *Computer Organization and Design: The Hardware/Software Interface, Third Edition*, Patterson and Hennessy (COD). *The second edition is far inferior, and is not suggested.*
- Required: *The C Programming Language*, Kernighan and Ritchie (K&R), 2nd edition
- Reading assignments on web page

What is this?



Attention over time!

What is this?!



Attention over time!

Tried-and-True Technique: Peer Instruction

- Increase real-time learning in lecture, test understanding of concepts vs. details
- As complete a "segment" ask multiple choice question
  - 1-2 minutes to decide yourself
  - 3 minutes in pairs/triples to reach consensus. Teach others!
  - 5-7 minute discussion of answers, questions, clarifications
- You'll get transmitters from ASUC bookstore (or Neds), (hopefully they're in!)

Peer Instruction

- Read textbook
  - Reduces examples have to do in class
  - Get more from lecture (also good advice)
- Fill out 3-question Web Form on reading (released mondays, due every friday before lecture)
  - Graded for effort, not correctness…
  - This counts toward "E"ffort in EPA score

Weekly Schedule

We are having discussion, lab and office hours this week…

Weekly Schedule

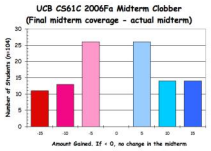
	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:00		111 DIS 320 Soda - Aaron	116 DIS 320 Soda - Scott	011 LAB 271 Soda - Aaron	016 LAB 271 Soda - Scott
10:00-11:00					
11:00-12:00				012 LAB 271 Soda - Aaron	OH 511 Soda - Scott
12:00-1:00		112 DIS 320 Soda - Aaron			OH 751 Soda - Sameer
1:00-2:00	OH 511 Soda - David J.	113 DIS 320 Soda - David J.	OH 511 Soda - Aaron	013 LAB 271 Soda - David J.	
2:00-3:00					
3:00-4:00	LEC 2050 VLSB	114 DIS 320 Soda - David P.	LEC 2050 VLSB	014 LAB 271 Soda - David P.	LEC 2050 VLSB
4:00-5:00		OH 511 Soda - David P.	OH 795 Soda - Prof Garcia		
5:00-6:00				015 LAB 271 Soda - Sameer	
6:00-7:00		115 DIS 320 Soda - Sameer			

Homeworks, Labs and Projects

- Lab exercises (every wk; due in that lab session unless extension given by TA) – extra point if you finish in 1st hour!
- Homework exercises (~ every week; (HW 0) out now, due in section *next week)*
- Projects (every 2 to 3 weeks)
- All exercises, reading, homeworks, projects on course web page
- We will DROP your lowest HW, Lab!
- Only one {HW, Project, Midterm} / week

2 Course Exams

- Midterm: Monday 2007-03-05 @ 7-10pm
  - Give 3 hours for 2 hour exam
  - One "review sheet" allowed
  - Review session Sun beforehand, time/place TBA
- Final: Sat 2007-05-12 @ 12:30-3:30pm (grp 5)
  - You can *clobber* your midterm grade!
  - (students always LOVE this…)



Your final grade

- Grading (could change before 1st midterm)
  - 15pts = 5% Labs
  - 30pts = 10% Homework
  - 60pts = 20% Projects
  - 75pts = 25% Midterm* *[can be clobbered by Final]*
  - 120pts = 40% Final
  - \+ Extra credit for EPA. What's EPA?
- Grade distributions
  - Similar to CS61[AB], in the absolute scale.
  - Perfect score is 300 points. 10-20-10 for A+, A, A-
  - Similar for Bs and Cs (40 pts per letter-grade) … C+, C, C-, D, F (No D+ or D- distinction)
  - Differs: No F will be given if all-but-one {hw, lab}, all projects submitted and all exams taken
  - We'll "ooch" grades up but never down

Extra Credit: EPA!

- Effort
  - Attending Dan's and TA's office hours, completing all assignments, turning in HW0, doing reading quizzes
- Participation
  - Attending lecture and voting using the PRS system
  - Asking great questions in discussion and lecture and making it more interactive
- Altruism
  - Helping others in lab or on the newsgroup
- EPA! extra credit points have the potential to bump students up to the next grade level! (but actual EPA! scores are internal)

Course Problems…Cheating

- What is cheating?
  - Studying together in groups is encouraged.
  - Turned-in work must be *completely* your own.
  - Common examples of cheating: running out of time on a assignment and then pick up output, take homework from box and copy, person asks to borrow solution "just to take a look", copying an exam question, …
  - You're not allowed to work on homework/projects/exams with anyone (other than ask Qs walking out of lecture)
  - Both "giver" and "receiver" are equally culpable
- Cheating points: 0 EPA, negative points for that assignment / project / exam (e.g., if it's worth 10 pts, you get -10) In most cases, F in the course.
- Every offense will be referred to the Office of Student Judicial Affairs.

`www.eecs.berkeley.edu/Policies/acad.dis.shtml`

My goal as an instructor

- To make your experience in CS61C as enjoyable & informative as possible
  - Humor, enthusiasm, graphics & technology-in-the-news in lecture
  - Fun, challenging projects & HW
  - Pro-student policies (exam clobbering)
- To maintain Cal & EECS standards of excellence
  - Your projects & exams will be just as rigorous as every year. Overall : B- avg
- To be an HKN "7.0" man
  - I know I speak fast when I get excited about material. I'm told every semester. Help me slow down when I go toooo fast.
  - Please give me feedback so I improve! Why am I not 7.0 for you? I will listen!!

Teaching Assistants (some here Fri)

- Michael Le (also Head TA)
- Valerie Ishida
- Matt Johnson
- Alex Kronrod
- Brian Nguyen
- David Poll
- Aaron Staley

Summary

- Continued rapid improvement in computing
  - 2X every 2.0 years in memory size; every 1.5 years in processor speed; every 1.0 year in disk capacity;
  - Moore's Law enables processor (2X transistors/chip ~1.5-2 yrs)
- 5 classic components of all computers

Control Datapath Memory Input Output

Processor