Slide 1

inst.eecs.berkeley.edu/~cs61c

CS61C : Machine Structures

Lecture #1 – Introduction

2005-01-19

Lecturer PSOE 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. Very cool.
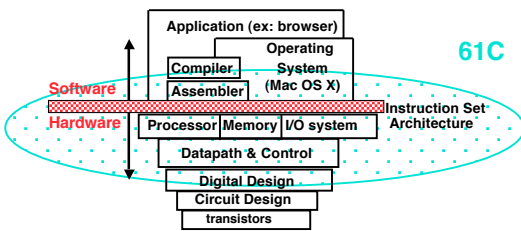
www.cs.berkeley.edu/~ddgarcia/tl/

CS61C L01 Introduction (1) Garcia, Spring 2005 © UCB

Slide 2

Teaching Assistants

° **Andy Carle [Head TA]**

° **Steven Kusalo**

° **Danny Krause**

° **Casey Ho**

CS61C L01 Introduction (2) Garcia, Spring 2005 © UCB

Slide 3

What are "Machine Structures"?

61C

Software
Hardware

Application (ex: browser)
Operating System (Mac OS X)
Compiler
Assembler
Processor Memory I/O system
Instruction Set Architecture
Datapath & Control
Digital Design
Circuit Design
transistors

* **Coordinate of many**

levels (layers) of abstraction

CS61C L01 Introduction (3) Garcia, Spring 2005 © UCB

Slide 4

61C Levels of Representation

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

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

Compiler

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

Assembly Language Program (e.g.,MIPS)

Assembler

```
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
```

Machine Language Program (MIPS)

Machine Interpretation

Hardware Architecture Description (e.g., Verilog Language)

```
wire [31:0] dataBus;
regFile registers (databus);
ALU ALUBlock (inA, inB, databus);
```

Architecture Implementation

Logic Circuit Description (Verilog Language)

```
wire w0;
XOR (w0, a, b);
AND (s, w0, a);
```

CS61C L01 Introduction (4) Garcia, Spring 2005 © UCB

Slide 5

Anatomy: 5 components of any Computer

Personal Computer

Computer

Processor
Control ("brain")
Datapath ("brawn")

Memory
(where programs, data live when running)

Devices
Input
Output

Keyboard, Mouse

Disk (where programs, data live when not running)

Display, Printer

CS61C L01 Introduction (5) Garcia, Spring 2005 © UCB

Slide 6
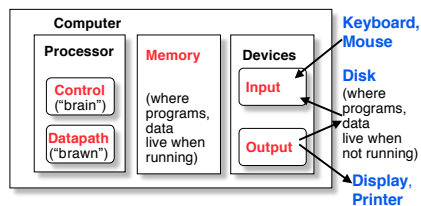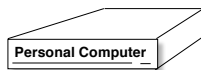
Technology Trends: Memory Capacity (Single-Chip DRAM)

size

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

• **Now 1.4X/yr, or 2X every 2 years.**

8000X since 1980!

CS61C L01 Introduction (9) Garcia, Spring 2005 © UCB
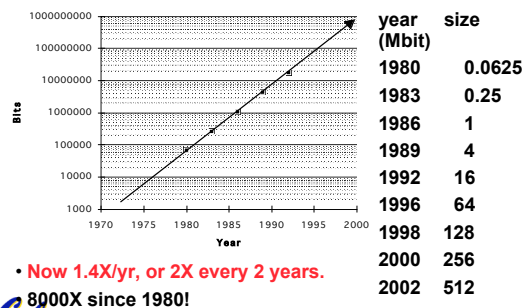
Technology Trends: Microprocessor Complexity

Itanium 2: 410 Million
Athlon (K7): 22 Million
Alpha 21264: 15 million
Pentium Pro: 5.5 million
PowerPC 620: 6.9 million
Alpha 21164: 9.3 million
Sparc Ultra: 5.2 million

Moore's Law

2X transistors/Chip Every 1.5 years

Called "Moore's Law"
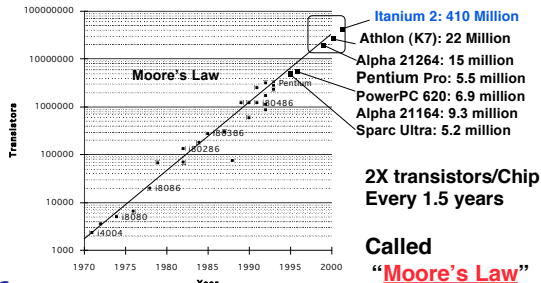
CS61C L01 Introduction (10)

Garcia, Spring 2005 © UCB

Technology Trends: Processor Performance

1.54X/yr

Intel P4 2000 MHz (Fall 2001)
DEC Alpha 21264/600
DEC Alpha 5/500
DEC Alpha 5/300
DEC Alpha 4/266
IBM POWER 100
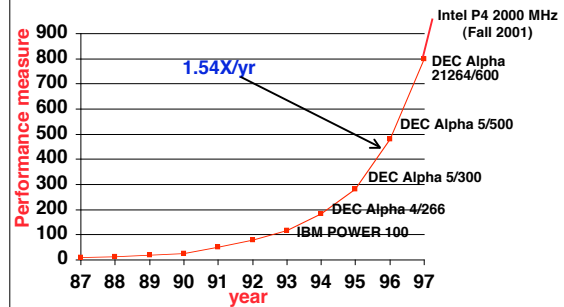
We'll talk about processor performance later on...

CS61C L01 Introduction (11)

Garcia, Spring 2005 © UCB

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); **100X performance in last decade.**

° **Disk**
  - Capacity: **2x / 1 year** (since '97) **250X size in last decade.**

CS61C L01 Introduction (12)

Garcia, Spring 2005 © UCB

Computer Technology - Dramatic Change!

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

° **State-of-the-art PC when you graduate: (at least...)**
  - Processor clock speed: 5000 **Mega**Hertz (5.0 **Giga**Hertz)
  - Memory capacity: 4000 **Mega**Bytes (4.0 **Giga**Bytes)
  - Disk capacity: 2000 **Giga**Bytes (2.0 **Tera**Bytes)
  - New units! **Mega** =

(Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta = 10^{24})
Come up with a clever mnemonic, fame!
It must have 1st 2 letters of each word. E.g., Kim Meat...

CS61C L01 Introduction (13)

Garcia, Spring 2005 © UCB

CS61C: So what's in it for me?

° **Learn some of the big ideas in CS & engineering:**
  - 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
  - Principle of abstraction, used to build systems as layers
  - Compilation v. interpretation thru system layers
  - Principles/Pitfalls of Performance Measurement

CS61C L01 Introduction (15)

Garcia, Spring 2005 © UCB

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 think of hardware at the abstract level, with only a little bit of physical logic to give things perspective
  - CS 150, 152 teach this

CS61C L01 Introduction (16)

Garcia, Spring 2005 © UCB

Course Lecture Outline

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

C
↓
C++
↓
Java

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**

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

- **Buy PRS transmitters from ASUC student store or others**

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 for "E"ffort in EPA score

Weekly Schedule

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

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-9:00					
9:00-10:00			Dis 320 Soda - Dan		
10:00-11:00		112 Dis 405 Soda - Steven		012 Lab 271 Soda - Danny	018 Lab 271 Soda - Steven
11:00-12:00					
12:00-1:00			Dis 118		
1:00-2:00	Lecture 2050 VLSB	113 Dis 320 Soda - Casey	Lecture 2050 VLSB	013 Lab 271 Soda - Casey	Lecture 2050 VLSB
2:00-3:00		114 Dis 320 Soda - Casey	OH 795 Soda - Prof Garcia	014 Lab 271 Soda - Casey	OH 795 Soda - Prof Garcia
3:00-4:00					
4:00-5:00		115 Dis 320 Soda - Danny		015 Lab 271 Soda - Danny	
5:00-6:00					
6:00-7:00				016 Lab 271 Soda - Andy	
7:00-8:00		116 Dis 320 Soda - Andy			

We are MOVING discussion 118 to Wednesdays noon-1pm in 320 Soda

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 + 2 Faux Exams

- **Midterm: Early 8th week, room TBA**
  - Give 3 hours for 2 hour exam
  - One "review sheet" allowed
  - Review session Sun beforehand, time/place TBA
- **Final: Sat 2005-05-14 @ 12:30-3:30pm (grp 5)**
  - You can *clobber* your midterm grade!
  - (students last semester LOVED this…)

UCB CS61C 2004Fa Midterm Clobber
(Final midterm coverage - actual midterm)
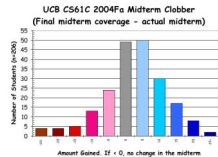
Your final grade

- ° **Grading (could change before 1st midterm)**
  - 15pts =   5% Labs
  - 30pts = 10% Homework
  - 45pts = 15% Projects
  - 75pts = 25% Midterm* *[can be clobbered by Final]*
  - 135pts = 45% Final
  -    +   Extra credit for EPA. What's EPA?
- ° **Grade distributions**
  - **Similar to CS61B**, 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!

- ° **E**ffort
  - **Attending Dan's and TA's office hours, completing all assignments, turning in HW0, doing reading quizzes**
- ° **P**articipation
  - **Attending lecture and voting using the PRS system**
  - **Asking great questions in discussion and lecture and making it more interactive**
- ° **A**ltruism
  - **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: 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

Student Learning Center (SLC)

- ° **Cesar Chavez Center (on Lower Sproul)**
- ° **The SLC will offer directed study groups for students CS 61C.**
- ° **They will also offer Drop-in tutoring support for about 20 hours each week.**
- ° **Most of these hours will be conducted by paid tutorial staff, but these will also be supplemented by students who are receiving academic credit for tutoring.**

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 yrs)**
- ° **5 classic components of all computers**

  Control Datapath Memory Input Output

  Processor