What are “Machine Structures”? 

* Coordination of many

levels (layers) of abstraction
61C Levels of Representation (abstractions)

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)

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
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 (2005 state-of-the-art)

- Primarily Crystalline Silicon
- 1mm - 25mm on a side
- 2005 - feature size ~ 90nm = 90 x 10^-9 m
- 100 - 1000M transistors
- (25 - 100M “logic gates”)
- 3 - 10 conductive layers
- “CMOS” (complementary metal oxide semiconductor) - most common.

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

Technology Trends: Memory Capacity
(Single-Chip DRAM)

<table>
<thead>
<tr>
<th>Year</th>
<th>size (Mbit)</th>
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<tbody>
<tr>
<td>1980</td>
<td>0.0625</td>
</tr>
<tr>
<td>1983</td>
<td>0.25</td>
</tr>
<tr>
<td>1986</td>
<td>1</td>
</tr>
<tr>
<td>1989</td>
<td>4</td>
</tr>
<tr>
<td>1992</td>
<td>16</td>
</tr>
<tr>
<td>1996</td>
<td>64</td>
</tr>
<tr>
<td>1998</td>
<td>128</td>
</tr>
<tr>
<td>2000</td>
<td>256</td>
</tr>
<tr>
<td>2002</td>
<td>512</td>
</tr>
<tr>
<td>2004</td>
<td>1024</td>
</tr>
</tbody>
</table>

- Now 1.4X/yr, or 2X every 2 years.
- 8000X since 1980!
Technology Trends: Microprocessor Complexity

**Moore's Law**

- 2X transistors/Chip
- Every 2 years
- Called "Moore’s Law"

---

### Processor Performance (SPECint)

- **VAX**: 25%/year 1978 to 1986
- **RISC + x86**: 52%/year 1986 to 2002
- **RISC + x86**: 20%/year 2002 to present
Computer Technology - Dramatic Change!

- **Processor**
  - 2X in speed every 1.5 years (since ‘85);
  - 100X performance in last decade.

- **Memory**
  - DRAM capacity: 2x / 2 years (since ‘96);
  - 64x size improvement in last decade.

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

*Will these trends continue?*

Technology Trends - what’s next?
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
  - 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 learn just the basics hardware design.
  - CS 150, 152 teach this in more detail.
Course Topic Outline

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

Texts


- Required: The C Programming Language, Kernighan and Ritchie (K&R), 2nd edition

- Reading assignments on web page

Read P&H Chapter 1 and sections 3.1 & 3.2 as soon as possible this week, and K&R Chapters 1-4 before Monday.
Class Meetings

- Monday Lecture
- Discussion Session (1 hour), Mon., Tue., or Wed.
- Wednesday Lecture
- Lab Session (2 hours), Wed., Thur., or Fri.
- Friday Lecture

There IS lab this week…

Homework, Labs and Projects

- **Lab exercises** (every week)
- **Homework exercises** (every week)
  - Due Wednesday at 11:59pm.
  - Homeworaks due Mon. on Exam weeks.
- **Projects** (every 2 to 3 weeks)
  - All exercises, reading, homeworaks, projects in course reader and on course web page.

www-inst.eecs.berkeley.edu/~cs61c
3 Course Exams

- **Midterm 1: Wed 7pm Feb 22\(^{nd}\), room TBA**
  - Give 2 hours for 1 hour exam
  - Open Book / Notes
  - Review sessions TBA
- **Midterm 2: Wed 7pm Apr 19\(^{th}\), room TBA**
- **Final: Tu May 9\(^{th}\), 6-9pm**
  - Day after final class.
  - You’ll be done with 61C early.

*Tentative Dates, Pending Room Availability*

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**Your final grade**

- **Grading**
  - 15 Homeworks \(15 \times 2\) 30pts.
  - 15 Labs \(15 \times 1\) 15
  - 5 Projects \(5 \times 10\) 50
  - 2 Midterms \(2 \times 30\) 60
  - Final exam \(2 \times 45\) 45
  - **TOTAL** 200

- **Grade distributions.** Absolute scale – no curve.
  - \(> 180\) A+
  - 175 A
  - 170 A-
  - 165 B+
  - ...
  - ...
  - 125 D-
Course Problems…Cheating

- What is cheating?
  - Studying together in groups is encouraged.
  - Turned in work must be 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, …

- Cheating on homeworks; -4 points for that assignment

- Cheating on projects / exams; At least, 0 points for that project / exam. In most cases, F in the course.

- For serious and repeated instances will refer you to Office of Student Judicial Affairs.

Enrollment

- Our goal is to accommodate everyone on the wait list.

- Three new sections have been added:
  
  016 LAB W 3-5P 017 LAB F 9-11A 018 LAB F 11-1P
  116 DIS M 4-5P 117 DIS W 9-10P 118 DIS W 12-1P

- If you want to be in the class, you must register for sections. Do it ASAP!

- It may be possible to switch to different sections later. However, if you are going to switch you must switch both your lab and discussion section. (At least you need to end up with the same TA for both.)
Teaching Assistants

<table>
<thead>
<tr>
<th></th>
<th>Dis</th>
<th>Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hayden So (Head TA)</td>
<td>M 4-5</td>
<td>W 3-5</td>
</tr>
<tr>
<td>Adam Megacz</td>
<td>Tu 5-6</td>
<td>Th 4-6</td>
</tr>
<tr>
<td></td>
<td>Tu 6-7</td>
<td>Th 6-8</td>
</tr>
<tr>
<td>Michael Le</td>
<td>W 9-10</td>
<td>F 9-11</td>
</tr>
<tr>
<td>Udam Saini</td>
<td>Tu 10-11</td>
<td>Th 10-12</td>
</tr>
<tr>
<td></td>
<td>W 12-1</td>
<td>F 11-1</td>
</tr>
<tr>
<td>David Marquardt</td>
<td>Tu 1-2</td>
<td>Th 12-2</td>
</tr>
<tr>
<td></td>
<td>Tu 2-3</td>
<td>Th 2-4</td>
</tr>
</tbody>
</table>

Summary

- **Continued rapid improvement in Computing**
  - 2X every 1.5 years in processor speed;
  - every 2.0 years in memory size;
  - every 1.0 year in disk capacity;
  - Moore’s Law enables processor
    (2X transistors/chip 2 yrs)

- **5 classic components of all computers**
  - Control
  - Datapath
  - Memory
  - Input
  - Output
  - **Processor**