CS61C
Machine Structures
Lecture 1

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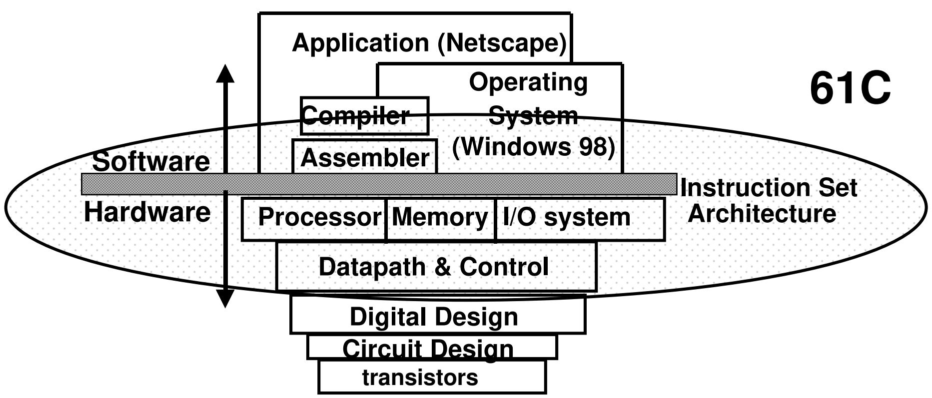
lecture slides: http://www-inst.eecs.berkeley.edu/~cs61c/

Overview

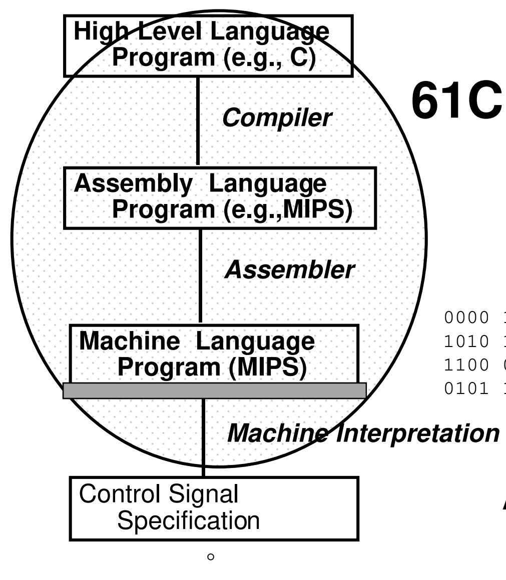
- Intro to Machine Structures (5 minutes)
- Organization and Anatomy of a Computer (10 min)
- Rapid Technological Change (5 min)
- Course Style, Philosophy and Structure (20 min)
- Conclusion (1 min)

What are "Machine Structures"?



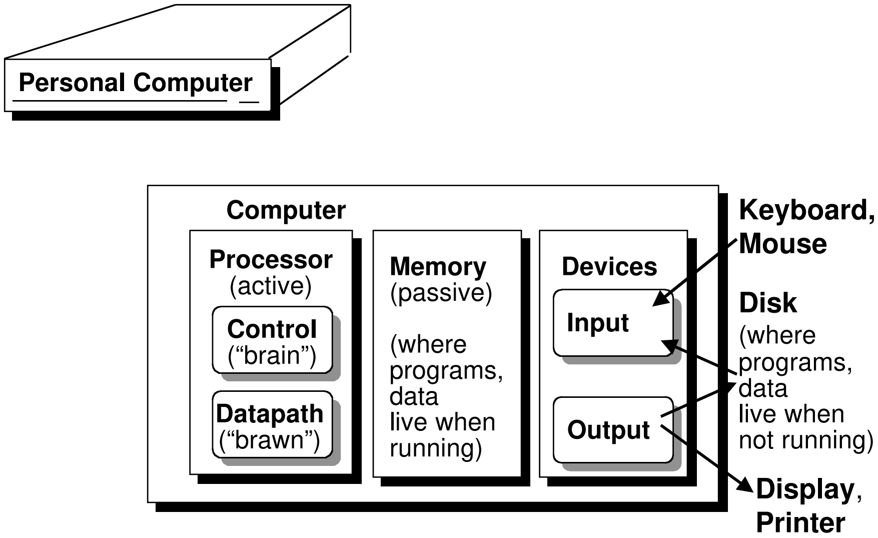
- Coordination of many *levels of abstraction*

Levels of Representation

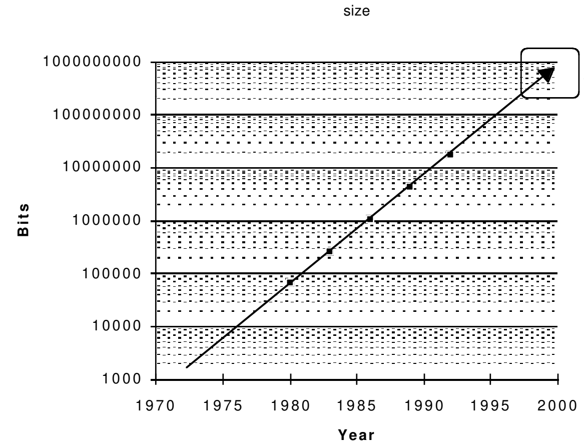



```
temp = v[k];
v[k] = v[k+1];
v[k+1] = temp;

lw   $to,  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

ALUOP[0:3] <= InstReg[9:11] & MASK
```

Anatomy: 5 components of any Computer



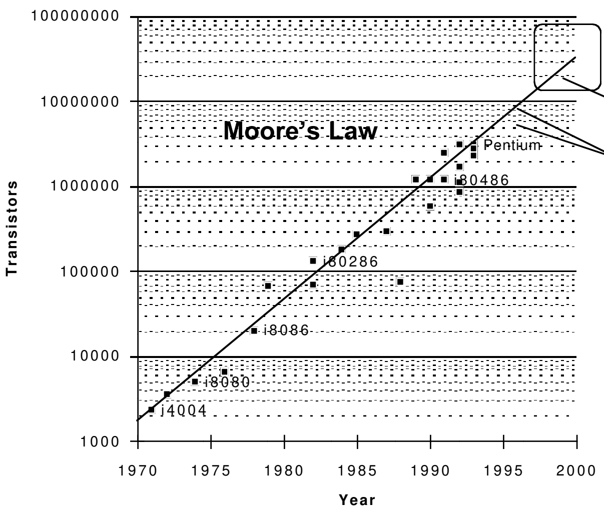
Technology Trends: Memory Capacity (1 Chip DRAM)



year	**size(Megabit)**
1980	**0.0625**
1983	**0.25**
1986	**1**
1989	**4**
1992	**16**
1996	**64**
1999	**256**

1.55X/yr,
or doubling every 1.6 years:

Technology Trends: Microprocessor Capacity

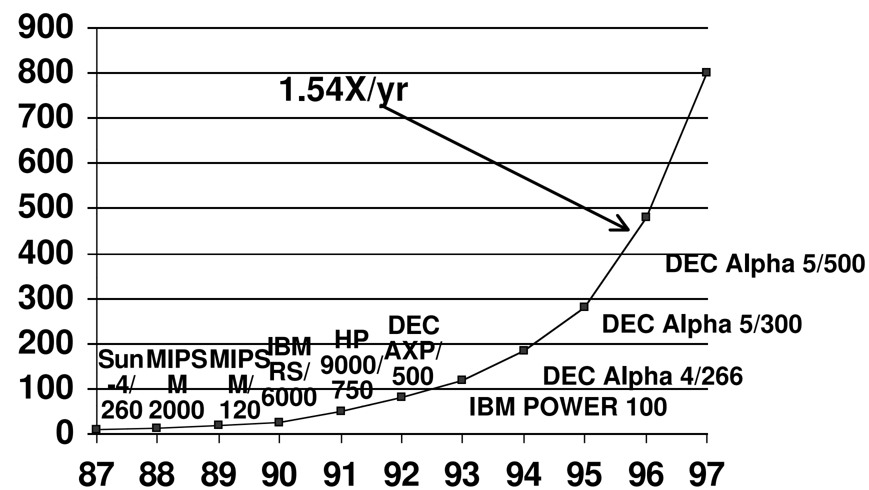


Alpha 21264: 15 million
Pentium Pro: 5.5 million
PowerPC 620: 6.9 million
Alpha 21164: 9.3 million
Sparc Ultra: 5.2 million

2X transistors/Chip
Every 1.5 years

Called "Moore's Law":

Technology Trends: Processor Performance



Processor performance increase/yr
mistakenly referred to as Moore's Law (transistors/chip)

Computer Technology => Dramatic Change

- Processor
  - 2X in speed every 1.5 years; 1000X performance in last decade
- Memory
  - DRAM capacity: 2x / 1.5 years; 1000X size in last decade
  - Cost per bit: improves about 25% per year
- Disk
  - capacity: > 2X in size every 1.5 years
  - Cost per bit: improves about 60% per year
  - 120X size in last decade
- State-of-the-art PC when you graduate:
  - Processor clock speed: 1500 MegaHertz (1.5 GigaHertz)
  - Memory capacity: 500 MegaByte (0.5 GigaBytes)
  - Disk capacity: 100 GigaBytes (0.1 TeraBytes)
  - New units! Mega => Giga, Giga => Tera

Why Study Machine Structures?

- CHANGE; It's exciting!; It has never been more exciting!
- It impacts every other aspect of electrical engineering and computer science

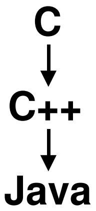
Bionics:
Sensors in latex fingers instantly register hot and cold, and an electronic interface in his artificial limb stimulates the nerve endings in his upper arm, which then pass the information to his brain. The $3,000 system allows his hand to feel pressure and weight, so for the first time since losing his arms in a 1986 accident, he can pick up a can of soda without crushing it or having it slip through his fingers. *One Digital Day*

CS61C: So what's in it for me?

- Machine structures from a programmer's view
  - What the programmer writes
  - How it is converted to something the computer understands
  - How the computer interprets the program
  - What makes programs go slow
- Learn big ideas in computer science and 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 are just data
  - Principle of Locality, exploited via a memory hierarchy (cache)
  - Greater performance by exploiting parallelism (pipeline)
  - Principle of abstraction, used to build systems as layers
  - Compilation v. interpretation to move down layers of system
  - Principles/Pitfalls of Performance Measurement

What 61C is <u>not</u>

- 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

Course Lecture Outline

- 1 week on Computer Anatomy (COD Ch. 1)
- 4 weeks on C v. ASM languages (COD Ch. 3)
- 1.5 weeks on C v. ASM numbers (COD Ch. 4)
- 1.5 weeks on I/O and interrupts (COD Ch. 8)
- 1 week on Cache (COD Ch. 7)
- 1 week on Virtual Memory (COD Ch. 7)
- 2 weeks Processor Datapath, Pipelining (COD 5.1,6.1)
- 2 weeks on review of traditionally difficult topics (pointers, caches, interrupts)

Course Exams

- **Reduce the pressure of taking exams**
  - **Midterm: Wednesday March 17**
  - **3 hrs to take 1.5-hr test (5-8 PM, 1 Pimentel)**
  - **Our goal: test knowledge vs. speed writing**
  - **Review meetings: Sunday before**
  - **Can bring 1 page summary sheet**
- **Final: Wednesday May 12 (5-8 PM, 1 Pimentel)**

Homework Assignments, Labs and Projects

- **Lab exercises** are to be done every week in lab section, and checked off by your lab TA the first part of following lab
- **Homework exercises** are to be handed in either online or to homework boxes in 283 Soda, due on Wednesday at 7PM (last call Thursday 8AM); teams 2-3 with 2nd exercise
  - **1st assignment: COD Exercises 1.1-1.16, 1.18, 1.21-1.23, 1.25, 1.27-1.30, 1.34-1.41,1.43-1.44, 1.56; Due Wednesday 1/27 7PM**
- **Projects** are larger programming assignments; team
- **Homeworks, Projects returned in discussion section**
- **Classrooms for new discussion sections this week**
  - **123 Fri 8-9 310 Soda**
  - **124 Fri 12-1 310 Soda**
- **Must turn in survey, login and attend lab/discussion sections to be considered enrolled**
  - **Go to old and new sections to ask TA's to switch sections (sections 23/123 and 24/124 have lowest enrollments)**

Grading

- **Grade breakdown**

Midterm Exam:	**25%**
Final Exam:	**35%**
Homework Assignments	**11%**
Lab Exercises	**11%**
Projects	**18%**

points	190-200	175-190	165-175	155-165	145-155	135-145
grade	A+	A	A-	B+	B	B-
points	125-135	115-125	105-115	[illegible]	<85	
grade	C+	C	C-	D	F	

- **Scores posted on home page**
  - **Written/email request for changes to grades; work first with TA**
  - **May 3 deadline to correct online scores**

Course Problems

- Can't make midterm, final
  - Tell early us and we will schedule alternate time before exam
- Forgot to turn in homework/ Dog ate computer
  - As a result of feedback, going to grade almost immediately so that can give results back quickly => late a hassle
- What is cheating?
  - Studying together in groups is encouraged
  - 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, ...
  - Better off to skip assignment (12 homeworks, 12 labs, 6 projects 40% of grade; how much can one assignment mean?)

Class decides on penalties for cheating; staff enforces

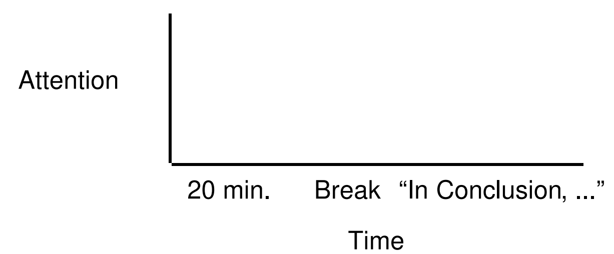
- Exercises (book):
  - 0 for problem
  - 0 for assignment
  - subtract full value for assignment
- Labs (groups: only penalize individuals?)
  - 0 for problem
  - 0 for assignment
  - subtract full value for assignment
- Projects (groups: only penalize individuals?)
  - 0 for problem
  - 0 for assignment
  - subtract full value for assignment
- Exams
  - 0 for problem
  - 0 for exam

Course Administration

- Instructor: David A. Patterson (patterson@cs)
  635 Soda Hall
  Office Hours:Wed 2-3
- TAs: Josh Cantrell, Michael Chu, Brendan Ferguson, Nemanja Isailovic, Gek Siong Low, Kelvin Lwin, Dmitiry Portnov, Mark Spiller, Tai Ping Yu
- Labs: Class Accounts for 271 Soda
- Materials: http://www-inst.eecs/~cs61c
- Newsgroup: ucb.class.cs61c
- Text: *Computer Organization and Design: The Hardware/Software Interface, <u>Second Edition</u>*, Patterson and Hennessy
  - Q: Need 2nd Edition? <u>yes! >> 50% text changed,</u>

Typical Lecture Format

- 20-Minute Lecture
- 5-Minute Administrative Matters
- 25-Minute Lecture
- Instructor will come to class early & stay after to answer questions



And in Conclusion...

- 15 weeks to learn big ideas in CS&E
  - Principle of abstraction, used to build systems as layers
  - Pliable Data: a program determines what it is
  - Stored program concept: instructions are just data
  - Principle of Locality, exploited via a memory hierarchy (cache)
  - Greater performance by exploiting parallelism (pipeline)
  - Compilation v. interpretation to move down layers of system
  - Principles/Pitfalls of Performance Measurement
- Continued rapid improvement in Computing
  - 2X in speed every 1.5 years; processor speed, memory size, disk capacity; Moore's Law enables it (2X transistors/chip/1.5 yrs)
- 5 classic components of all computers

  1. Control; 2. Datapath; 3. Memory; 4. Input; 5. Output

  Processor