CSE 141-- Introduction to Computer Architecture

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What is Computer Architecture? (am I in the right class?)

- Hardware Designer
  - thinks about circuits, components, timing, functionality, ease of debugging

"construction engineer"

- Computer Architect
  - thinks about high-level components, how they fit together, how they work together to deliver performance.

"building architect"

Why do I care?

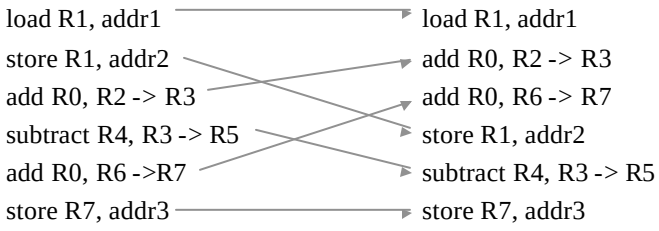
- **You may actually do computer architecture someday**
- **You may actually care about software performance someday**
  - The ability of application programs, compilers, operating systems, etc. to deliver performance depends critically on an understanding of the underlying computer organization.
  - That becomes more true every year.
  - Computer architectures become more difficult to understand every year.

Which is faster?

```
for (i=0; i<N; i=i+1)
  for (j=0; j<N; j=j+1) {
    r = 0;
    for (k=0; k<N; k=k+1)
      r = r + y[i][k] * z[k][j];
    x[i][j] = r;
    }
```

```
for (jj=0; jj<N; jj=jj+B)
for (kk=0; kk<N; kk=kk+B)
for (i=0; i<N; i=i+1) {
  for (j=jj; j<min(jj+B-1,N); j=j+1)
    r = 0;
    for (k=kk; k<min(kk+B-1,N); k=k+1)
      r = r + y[i][k] * z[k][j];
    x[i][j] = x[i][j] + r;
    }
```

Which is faster?



Which is faster?

```
loop1:  add ...
        load ...
        add ...
        bne R1, loop1
loop2:  add ...
        load ...
        bne R2, loop2
```

```
loop1:  add ...
        load ...
        add ...
        bne R1, loop1
        nop
        nop
loop2:  add ...
        load ...
        bne R2, loop2
```

Administration

- Instructor -- Dr. Allan Snavely
- Course webpages www.sdsc.edu/~allans/cse141.html
- TAs:
  - Mrunal Kulkarni (teaches section)
  - Vivek Manpuria
  - Rahul Lahoti
- Lab Consultants:
  - Tim Pevzner
- Grading 40% midterm, 10% class participation, 50% final
- Homework
- Relationship of lab and lecture
- The course workload

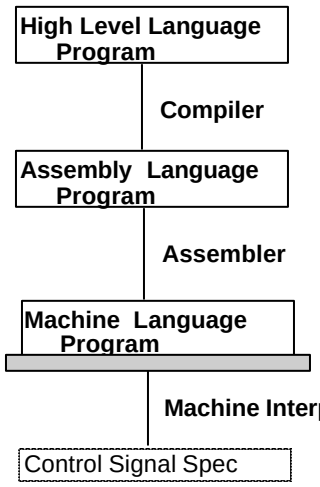
What is Computer Architecture?

Computer Architecture =
Machine Organization +
Instruction Set Architecture

What the machine looks like

How you talk to the machine

How to Speak Computer




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

```
lw  $15,   0($2)
lw  $16,   4($2)
sw $16,   0($2)
sw $15,   4($2)
```

```
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
```

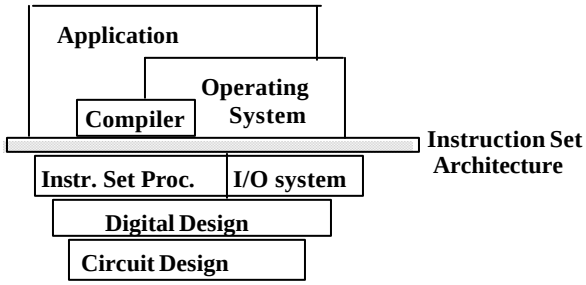
```
ALUOP[0:3] <= InstReg[9:11] & MASK
```


The Instruction Set Architecture

- that part of the architecture that is visible to the programmer
  - opcodes (available instructions)
  - number and types of registers
  - instruction formats
  - storage access, addressing modes
  - exceptional conditions

The Instruction Set Architecture

° is the agreed-upon interface between all the software that runs on the machine and the hardware that executes it.



Examples of ISAs

- Alpha AXP
- Intel 80x86/pentium
- VAX
- MIPS
- SPARC
- IBM 360
- Intel IA-64 (Itanium)
- PowerPC

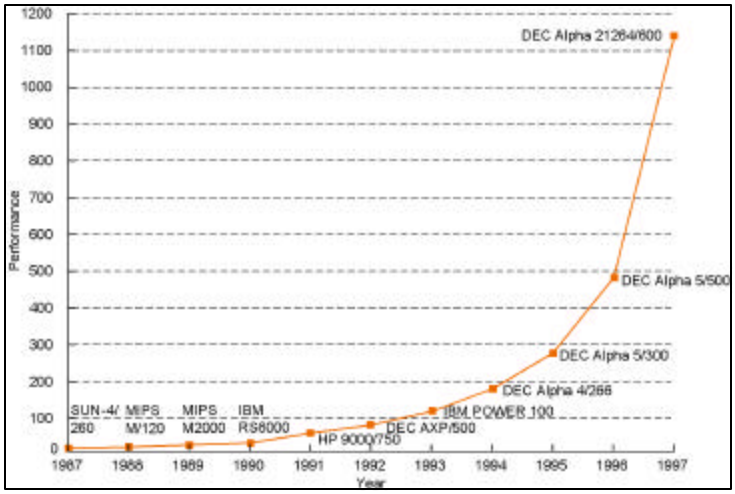
Computer Organization

- Once you have decided on an ISA, you must decide how to design the hardware to execute those programs written in the ISA as fast as possible.
- This must be done every time a new implementation of the architecture is released, with typically very different technological constraints.

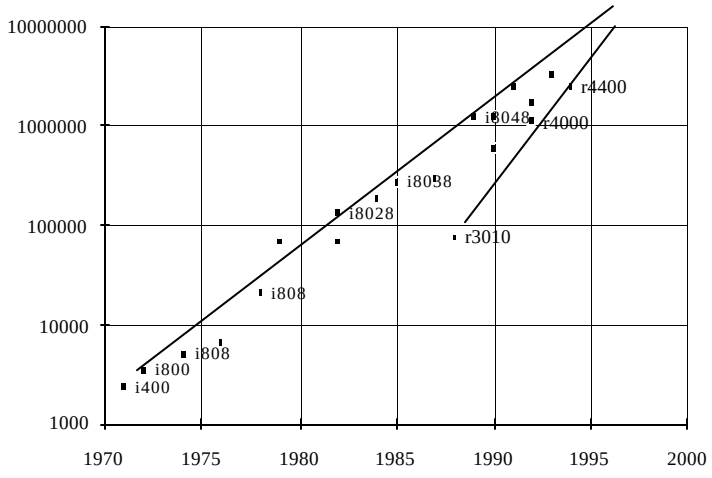
The Challenge of Computer Architecture

- The industry changes faster than any other.
- The ground rules change every year.
  - new problems
  - new opportunities
  - different tradeoffs
- It's all about making programs run faster than the next guy's machine.

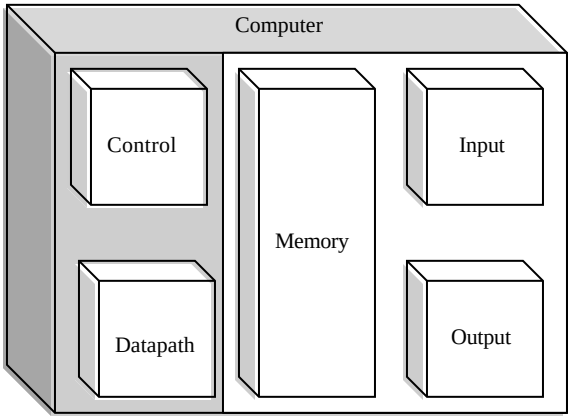
Performance Trends



Technology: Microprocessor Logic Density



The five classic components of computers



Course Outline

I. Instruction Set Architecture

II. Computer System Performance and Performance Metrics

III. Computer Arithmetic and Number Systems

IV. CPU Architecture

V. Pipelining

VI. Superscalars

VII. The Memory/Cache Hierarchy

VIII. Parallel Machines

What you can expect to get out of this class

- to become conversant with computer architecture terms and concepts.
- to understand fundamental concepts in computer architecture and how they impact computer and application performance.
- to be able to read and evaluate architectural descriptions of even today's most complex processors.
- to gain experience designing a working CPU completely from scratch.
- to learn experimental techniques used to evaluate advanced architectural ideas.

Key Points

- High-performance software requires a deep understanding of the underlying machine organization.
- The instruction set architecture defines how software is allowed to use the processor. Multiple computers with vastly different organizations and performance can share an ISA.
- Most every component in a computer system falls into one of five categories.