Outline
° Review Big Ideas and Examples
° Administrivia
° Page quiz: More pages Book vs. 61C slides?
° Cost, Performance analyses of Computer Science Bachelors of Science Degrees: Cal vs. Stanford
° Your Cal Cultural Heritage, including videotape
° Predicting the Future
° HKN Evaluation

From First Lecture
° 15 weeks to learn big ideas in CS&E
  • Principle of abstraction, used to build systems as layers
  • Compilation v. interpretation to move down layers of system
  • Pliable Data: a program determines what it is
  • Stored program concept: instructions are data
  • Principle of Locality, exploited via a memory hierarchy (cache)
  • Greater performance by exploiting parallelism
  • Principles/pitfalls of performance measurement

Principle of abstraction, systems as layers
° Programming Languages:
  • C / Assembly / Machine Language
  • Pseudoinstructions in Assembly Language
° Translation:
  • Compiler / Assembler / Linker / Loader
° Network Protocol Suites:
  • TCP / IP / Ethernet
° Memory Hierarchy:
  • Registers / Caches / Main memory / Disk
Compilation v. interpretation to move down

- **Programming Languages:**
  - C / Assembly / Machine Language
  - Compilation

- **Network Protocol Suites:**
  - TCP / IP / Ethernet
  - Interpretation

- **Memory Hierarchy:**
  - Caches / Main memory / Disk: Interpretation
  - Registers / Cache: Compilation

Pliable Data: a program determines what it is

- **Instructions (fetched from memory using PC):**
  - Types include Signed Integers, Unsigned Integers, Characters, Strings, Single Precision Floating Point, Double Precision Floating Point
  - Everything has an address (→ pointers)
  - TCP packet? IP packet? Ethernet packet?

Stored program concept: instructions as data

- Allows computers to switch personalities
- Simplifies compile, assembly, link, load
- Distributing programs easy: on any disk, just like data
  - ⇒ binary compatibility, upwards compatibility (8086, 80286, 80386, 80486, Pentium I, II, III)
- Allows for efficient Dynamic Libraries: modify the code to patch in real address
- Makes it easier for viruses: Send message that overflows stack, starts executing code in stack area, take over machine

Principle of Locality

- Exploited by memory hierarchy
- Registers assume Temporal Locality: data in registers will be reused
- Disk seeks faster in practice: short seeks are much faster, so disk accesses take less time ⇒ due to Spatial Locality
- Disks transfer in 512 Byte blocks assuming spatial locality: more than just 4 bytes useful to program
- Networks: most traffic is local, so local area network vs. wide area network
**Greater performance by exploiting parallelism**

- **Pipelining**
  - Overlap execution to increase instruction throughput vs. instruction latency

- **Input/Output**
  - Overlap program execution with I/O, only interrupt when I/O complete
  - DMA data while processor does other work

- **RAID (Redundant Array of Inexp. Disks)**
  - Replace a few number of large disks with a large number of small disks ⇒ more arms moving, more heads transferring (even though small disks maybe slower)

**Performance measurement Principles/Pitfalls**

- **Processors**
  - only quoting one factor of 3-part product: clock rate but not CPI, instruction count
  - Cache miss rate vs. Average memory time

- **Networks**
  - only looking peak bandwidth, not including software start-up overhead for message

- **Disks**
  - Seek time much better than what manufacturer quotes (3X to 4X)
  - Data transfer rate worse than what manufacturer quotes (0.75X)

**Rapid Change AND Little Change**

- **Continued Rapid Improvement in Computing**
  - 2X every 1.5 years (10X/5yrs, 1000X/15yrs)
  - Processor speed, Memory size - Moore’s Law as enabler (2X transistors/chip/1.5 yrs); Disk capacity too (not Moore’s Law)
  - Caches, Pipelining, Branch Prediction, ...

- **5 classic components of all computers**

  1. Control
  2. Datapath  }  **Processor (or CPU)**
  3. Memory
  4. Input
  5. Output

**Administrivia**

- **All grades up-to-date?**
  - See Kelvin ASAP about disagreements

- **Sunday 5/9 Final Review starting 2PM (1 Pimintel)**
  - Practice Final, Solution available online now

- **Wed 5/12 Final 5-8PM in 1 Pimintel**
  - 2 sheets of paper, both sides, #2 pencils (no calculators)
  - Any problems with time, last chance to contact mds@cory for early final
Online Notes

° Guess Which has more: pages in COD (including Appendix A) vs. CS 61C online slides?
° Pages in COD 2/e: 837
° Total CS61C slides online: 926

Proving UCB CS B.S. >> Stanford’s
° 97/98 Degrees: 242 (Cal) v. 176 (Stanford)
  • Cal: L&S Computer Science + EECS Option C

° Performance Benchmarks
  • Programming Contests
  • Going to Industry
  • Going to Graduate School
  • Number National Undergraduate Awards

° Cost: Tuition, Overall

ACM Programming Contests

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° Stanford wins regional 1/6 years, never won international
° Berkeley wins register 4/6 years, won international, 5/6 times ahead of Stanford

Going to Industry

° Gordon Moore: “Lots more people from Silicon Valley from Cal than Stanford”
° “Berkeley B.S. degree is about equivalent to a Stanford M.S. degree”
  • Intel recruiter, several others companies
° 1997-98 Starting Salaries B.S. in CS (according to Placement centers)
  • Stanford: $41,000 to $56,000
  • Berkeley: median $50,000 (know of $70,000 jobs)
Going on to Ph.D. in C.S. Fall 99

- About 25% of Berkeley CS students go on for PhD, <5% of Stanford students go for PhD

- Admitting School
  - Stanford
  - Berkeley

- Univ. Washington 5 7
- MIT 3 6
- Carnegie Mellon 1 4
- Stanford ?? 6
- Berkeley 0 8

Outstanding Undergraduate Awards

- Started 1995, by Computing Research Association
- 2 Nominations / school / year: 2 Winners, few Runners Up, several Honorable Mentions
  - Total: 10 winners, 24 Runners Up, 49 Hon. Mns.

- Number winners Total Named Points (3/2/1)

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Berkeley vs. Stanford CS Degrees

- Performance: Berkeley wins (large factors)
- Cost Benchmark
  - Tuition Only: $22,100 (Stanford) v. $3,766 (Cal)
  - Berkeley wins by factor of 5.9
  - 4.5 years * Tuition/Room/Books/Board
  - Stanford Cost: 4.5 * $32,444 = $145,998
  - Berkeley Cost: 4.5 * $14,598 = $65,691
  - Berkeley wins by factor of 2.2
- Cost-Performance: Berkeley best in world?

Cal Cultural History: ABCs of Football

- Started with “soccer”; still 11 on a team, 2 teams, 1 ball, on a field; object is to move ball into “goal”; most goals wins
- New World changes the rules to increase scoring:
  - Make goal bigger! (full width of field)
  - Carry ball with hands
  - Can toss ball to another player backwards or laterally (called a “lateral”) anytime and forwards (“pass”) sometimes
- How to stop players carrying the ball? Grab them & knock them down by making knee hit the ground (“tackle”)
ABCs of American Football

° Score by
  • moving football into goal ("cross the goal line" or "into the end zone") scoring a "touchdown" (6 points)
  • kicking football between 2 poles ("goal posts") scoring a "field goal" (worth 3 points, unless after touchdown, then its just 1 point: "extra point")
° Kick ball to other team after score ("kickoff"); laterals OK
° Game ends when no time left (4 15 min quarters) and person with ball is stopped (Soccer time only: 2 45 min halves, time stops play)

Football Field

The Spectacle of American Football

° Cal’s archrival is Stanford; stereotype is Private, Elitist, Snobs
° Play nearby archrival for last game of season
  • Called “The Big Game”: Cal vs. Stanford, winner gets a trophy ("The Axe"): Oldest rivalry west of Mississippi; 100th in 1997
° American college football is a spectacle
  • School colors (Cal Blue & Gold v. Red & White)
  • Nicknames (Golden Bears v. Stanford Cardinal)
  • School mascot (Oski the bear v. a tree(!))
  • Leaders of cheers ("cheerleaders")
1982 Big Game

- “There has never been anything in the history of college football to equal it for sheer madness.” *Sports Illustrated*
- Stanford Quarterback is John Elway, who goes on to be a professional All Star football player (retired 1999, last Monday)
  - greatest quarterback in college history
- Cal Quarterback is Gail Gilbert, who goes on to be a non-starting professional football player (retired 1996)
- Stanford lost 4 games in last minutes of game
- Stanford has just taken lead with 4 seconds left in game; Cal team captain yells in huddle “Don’t fall with the ball!”; look at video

Notes About “The Play”

- Cal only had 10 men on the field; last second another came on (170 pound Steve Dunn #3) and makes key 1st block
- Kevin Moen #26: 6’1” 190 lb. safety,
  - laterals to Rodgers (and doesn’t give up)
- Richard Rodgers #5: 6’ 200 lb. safety, “Don’t fall with the ball.”
  - laterals to Garner
- Dwight Garner #43: 5’9” 185 lb. running back
  - almost tackled, 2 legs & 1 arm pinned, laterals
- Richard Rodgers #5 (again): “Give me the ball”
  - laterals to Ford

Notes About “The Play”

- Mariet Ford #1: 5’9”, 165 pound wide receiver
  - Smallest player, leg cramps; overhead blind lateral to Moen and blocks 3 players
- Moen (again) cuts through Stanford band into end zone (touchdown!), smashes Trombonist
- On field for Stanford: 22 football players, 3 Axe committee members, 3 cheerleaders, 144 Stanford band members (172 for Stanford v. 11 for Cal)
  - “Weakest part of the Stanford defense was the woodwinds.”
- 4 Cal players + Stanford Trombonist (Gary Tyrrell) hold reunion every year at Big Game; Stanford revises history (20-19 on Axe)

2nd to last 61C slide: First, Thanks to the TAs!

- Josh Cantrell,
- Michael Chu,
- Brendan Ferguson,
- Nemanja Isailovic,
- Gek Siong Low,
- Kelvin Lwin,
- Dmitriy Portnov,
- Mark Spiller,
- Tai Ping Yu
The Future for Cal Alumni:

- Better educated than Stanford people, and **They Never Give Up!**

- What’s The Future?

  - New Millennium
    - Internet, Satellites imagery, ...
    - Rapid Change in Technology
    - World’s Best Education
    - Hard Work + Never Give Up

- “The best way to predict the future is to invent it” (Alan Kay)

- Future is up to you!