CS61C : Machine Structures

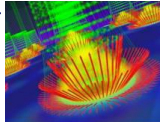## Lecture 43
Summary & Goodbye

Lecturer PSOE Dan Garcia

www.cs.berkeley.edu/~ddgarcia

Future? Spintronics! ⇒ Current silicon chips carry info with electron *charge*. This idea has them carry info with their <u>spin</u>. Lower power, higher processing speeds, and quantum computing!

www.physorg.com/news3998.html

CS61C L43 Summary & Farewell (1)   Garcia © UCB

Cool Stuff…the videos before lecture

SIGGRAPH 2005

- **SIGGRAPH Electronic Theatre**
  www.siggraph.org/publications/video-review/SVR.html
  - **$40/video for ACM Members**
- **SIGGRAPH Conference in LA!**
  - 2005-07-31 ⇒ 2005-08-04
    www.siggraph.org/s2005/

CS61C L43 Summary & Farewell (2)   Garcia © UCB

Review

- **Benchmarks**
  - Attempt to predict performance
  - Updated every few years
  - Measure everything from simulation of desktop graphics programs to battery life
- **Megahertz Myth**
  - MHz ≠ performance, it's just one factor

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CS61C: So what's in it for me? (1st lecture)

Learn some of the big ideas in CS & engineering:

- 5 Classic components of a Computer
- Principle of abstraction, systems built as layers
- Data can be anything (integers, floating point, characters): a program determines what it is
- Stored program concept: instructions just data
- Compilation v. interpretation thru system layers
- Principle of Locality, exploited via a memory hierarchy (cache)
- Greater performance by exploiting parallelism (pipelining)
- Principles/Pitfalls of Performance Measurement

CS61C L43 Summary & Farewell (4)   Garcia © UCB

Conventional Wisdom (CW) in Comp Arch

Thanks to Dave Patterson for these

- **Old CW: Power free, Transistors expensive**
- **New CW: Power expensive, Transistors free**
  - Can put more on chip than can afford to turn on
- **Old CW: Chips reliable internally, errors at pins**
- **New CW: ≤ 65 nm ⇒ high error rates**
- **Old CW: CPU manufacturers minds closed**
- **New CW: Power wall + Memory gap = Brick wall**
  - New idea receptive environment
- **Old CW: Uniprocessor performance 2X / 1.5 yrs**
- **New CW: 2X CPUs per socket / ~ 2 to 3 years**
  - More simpler processors more power efficient

CS61C L43 Summary & Farewell (5)   Garcia © UCB

Massively Parallel Socket

- **Processor = new transistor?**
  - Does it only help power/cost/performance?
- **Intel 4004 (1971): 4-bit processor, 2312 transistors, 0.4 MHz, 10 μm PMOS, 11 mm² chip**
- **RISC II (1983): 32-bit, 5 stage pipeline, 40,760 transistors, 3 MHz, 3 μm NMOS, 60 mm² chip**
  - 4004 shrinks to ~ 1 mm² at 3 micron
- **125 mm² chip, 65 nm CMOS = 2312 RISC IIs + Icache + Dcache**
  - RISC II shrinks to ~ 0.02 mm² at 65 nm
  - Caches via DRAM or 1 transistor SRAM (www.t-ram.com)?
  - Proximity Communication at > 1 TB/s ?
  - Ivan Sutherland @ Sun spending time in Berkeley!

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20th vs. 21st Century IT Targets

- 20th Century Measure of Success
  - Performance (peak vs. delivered)
  - Cost (purchase cost vs. ownership cost, power)
- 21st Century Measure of Success? "SPUR"
  - Security
  - Privacy
  - Usability
  - Reliability
- Massive parallelism greater chance (this time) if
  - Measure of success is SPUR vs. only cost-perf
  - Uniprocessor performance improvement decelerates

Other Implications

- **Need to revisit chronic unsolved problem**
  - **Parallel programming!! (Thanks again Andy)**
- **Implications for applications:**
  - Computing power >>> CDC6600, Cray XMP (choose your favorite) on an economical die inside your watch, cell phone or PDA
    - On your body health monitoring
    - Google + library of congress on your PDA
- **As devices continue to shrink…**
  - **The need for great HCI critical as ever!**

Administrivia (1/2) : Final Exam & Review

Final Exam: SAT 2005-05-14, 12:30-3:30pm in 220 Hearst

Only bring pen{,cil}s, two 8.5"x11" handwritten sheets + green. Leave backpacks, books, calculators, cells & pagers home!

Dan's Extended OH
- Tuesday 2005-05-10 @ noon-3pm in 795 Soda (overflowing into 751 Soda if too full)

Administrivia (2/2) : Become active!

- **There IS discussion this week (no lab)**
  - Make sure to talk to your TAs and get your labs taken care of.
- **If you did well in CS3 or 61{A,B,C} (A- or above) and want to be on staff?**
  - Usual path: Lab assistant ⇒ Reader ⇒ TA
  - Fill in form outside 367 Soda before first week of semester…
  - I (Dan) strongly encourage anyone who gets an A- or above in the class to follow this path… I'll be teaching 61C in the fall!

Taking advantage of Cal Opportunities

"The Godfather answers all of life's questions"
– Heard in "You've got Mail"

- **Why are we the #2 Univ in the WORLD?**
  So says the 2004 ranking from the "Times Higher Education Supplement"
  - **Research, reseach, research!**
  - Whether you want to go to grad school or industry, you need someone to vouch for you! (as is the case with the Mob)
- **Techniques**
  - Find out what you like, do lots of web research (read published papers), hit OH of Prof, show enthusiasm & initiative

`http://research.berkeley.edu/`

CS98/198 Opportunities Fall 2005

- **GamesCrafters (Game Theory R & D)**
  - We are developing SW, analysis on small 2-person games of no chance. (e.g., achi, connect-4, dots-and-boxes, etc.)
  - Req: A- in CS61C, Game Theory Interest
- **MS-DOS X (Mac Student Developers)**
  - Learn to program Macintoshes. No requirements (other than Mac, interest)
- **UCBUGG (Recreational Graphics)**
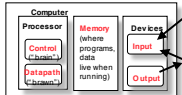 - Develop computer-generated images and animations. Req: 3D experience, portfolio

Peer Instruction

Strong or Weak AI? Strong AI: Machines that act intelligently have real, conscious minds...sentience Weak AI: Machines can be made to act as if they were intelligent.

In the future, what'll be the most important computer component?

```
Strong AI
1: Control
2: Datapath
3: Memory
4: Input
5: Output

Weak AI
6: Control
7: Datapath
8: Memory
9: Input
0: Output
```

Computer
Processor
Control ("brain")
Datapath ("brawn")
Memory (where programs, data live when running)
Devices
Input
Output

Peer Instruction Answer

"Forget cloning. Forget TVs on your wrist watch. The biggest invention of the next 100 years will be the ability to directly connect your brain to a machine. – Dan Garcia

- **A macaque monkey at Duke University can already control a robotic arm with thought.**
- **DARPA is extremely interested in the technology for mind-control robots & flying**
- **Virtual Reality could be achieved with proper I/O interfacing…**

www.popsci.com/popsci/medicine/article/0,12543,576464,00.html

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Penultimate slide: Thanks to the staff!

- **TAs**
  - **Head TA Andy Carle**
  - **Steven Kusalo**
  - **Danny Krause**
  - **Casey Ho**

- **Readers**
  - **Michael Le**
  - **Benjamin Mellblom**
  - **Mark Whitney**

Thanks to Dave Patterson for these CS61C notes…

The Future for Future Cal Alumni

- **What's The Future?**
- **New Millennium**
  - **Internet, Wireless, Nanotechnology, ...**
  - **Rapid Changes in Technology**
  - **World's ₥ Best Education**
  - **Never Give Up!**

"The best way to predict the future is to invent it" – Alan Kay

The Future is up to you!