

**Lecture #31 Summary & Goodbye**

2007-8-16



**Scott Beamer, Instructor**

**Cityware Research Project Connects Bluetooth Users on Facebook**



CS61C L31 Summary & Goodbye (1)

www.bbc.co.uk

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**Review**

• **Parallelism**

- Above the line (software, many machines) and below the line (hardware, multiple cores) both critical for computing's future.
- Hard to write code that fully takes advantage of all available resources to maximize performance and get fully Nx speedup.
- Distributed and Parallel computing
  - Synchronization hard, APIs help (MapReduce)
- Hardware Parallelism
  - Cache coherence makes it difficult to scale!
  - Manycore, not multicore!
- Berkeley EECS taking initiative to make ~1000 core HW, put in researchers hands!



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**CS61C: So what's in it for me? (1<sup>st</sup> 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, superscalar, MapReduce, multi-..)

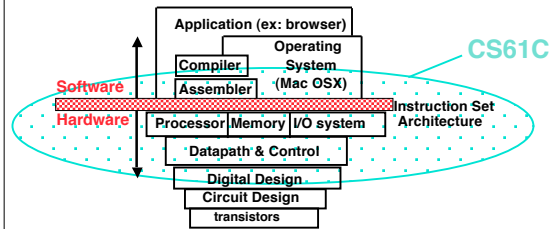
Principles/Pitfalls of Performance Measurement



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**What are "Machine Structures"?**



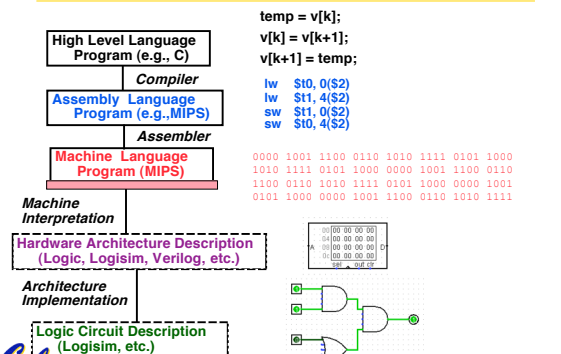
Coordination of many levels (layers) of abstraction



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**61C Levels of Representation**



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**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:  $\leq 45$  nm  $\Rightarrow$  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

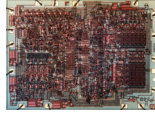


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## Massively Parallel Socket

- Processor = new transistor?
  - Does it only help power/cost/performance?
- Intel 4004 (1971): 4-bit processor, 2312 transistors, 0.4 MHz, 10  $\mu\text{m}$  PMOS, 11  $\text{mm}^2$  chip
- RISC II (1983): 32-bit, 5 stage pipeline, 40,760 transistors, 3 MHz, 3  $\mu\text{m}$  NMOS, 60  $\text{mm}^2$  chip
  - 4004 shrinks to  $\sim 1 \text{mm}^2$  at 3 micron
- 125  $\text{mm}^2$  chip, 65 nm CMOS = 2312 RISC IIs + lcache + Dcache
  - RISC II shrinks to  $\sim 0.02 \text{mm}^2$  at 65 nm
  - Caches via DRAM or 1 transistor SRAM ([www.t-ram.com/](http://www.t-ram.com/))?
  - Proximity Communication at  $> 1 \text{TB/s}$ ?



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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



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## Other Implications

- Need to revisit chronic unsolved problem
  - Parallel programming!!
- Implications for applications:
  - Computing power  $\gggg$  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!



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## Administrivia

### Regrade requests due TODAY at 7

Only for assignments after HW2

Only for grading mistakes

### Final Exam

Only bring pen{,cil}s,  
two 8.5"x11" handwritten sheets + green.  
Leave backpacks, books, calculators, cells & pagers home!  
Everyone must take ALL of the final!



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## Join Us...

- If you did well in CS3 or 61{A,B,C} (A- or above) and want to be on staff?
  - Usual path: Lab assistant  $\Rightarrow$  Reader  $\Rightarrow$  TA
  - Contact Jenny Jones in 395 Soda before first week of semester for LA signup...
  - Reader/TA forms: [www.cs/~juliea/](http://www.cs/~juliea/)
  - I (Dan) strongly encourage anyone who gets an A- or above in the class to follow this path...
    - It will help you internalize the material
    - Help fellow students, (and get paid for it)



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## Taking advantage of Cal Opportunities

- Why are we the #2 Univ in the WORLD?
  - So says the 2004 ranking from the "Times Higher Education Supplement"
  - Research, research, 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
- [research.berkeley.edu/](http://research.berkeley.edu/)
- [www.eecs.berkeley.edu/Research/](http://www.eecs.berkeley.edu/Research/)



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## Some Current Research

- **RADLab** (Reliable Adaptive Distributed)

- Looking at datacenter architectures



RAMP

- **RAMP** (Research Accelerator for Multiple Processors)

- Use FPGA's to get many cores
- Picture on right is 1008 cores in 1 rack



- **Berkeley View**



- Vision for future of parallel



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## Upper Div's that Build on CS61C

- **CS150** - Design Techniques for SDS
- **CS152** - Computer Architecture
- **CS162** - Operating Systems
- **CS164** - Prog. Lang. & Compilers
- **CS194-3** - Intro to Computer Systems
- **CS198-5** - Networked Computing
- **EE122** - Networking



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## Penultimate slide: Thanks to the staff!

- **TAs**

- Valerie Ishida
- Clark Leung

- **Readers**

- Michael Shuh
- Abhishek Karwa

- **Thanks to all the past CS61C Instructors, who have:**

- Trained myself and the staff
- Made these notes and other course material



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## The Future for Future Cal Alumni

- **What's The Future?**

- **New Millennium**

- Wireless, Nanotechnology, Quantum Computing, 10 M "volunteer" CPUs, the **Parallel revolution**...
- 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!



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