Bill Thies, outstanding MIT PhD student may have discovered a simple way to do parallel programming: StreamIt, based on data flow. A smart compiler splits across cores. We gave him offer!!
Cool Stuff...the videos before lecture

- **SIGGRAPH Electronic Theatre**
  
  www.siggraph.org/publications/video-review/SVR.html
  - $40/video for ACM Members

- **SIGGRAPH Conference in Los Angeles!**
  - 2008-08-11 ⇒ 2008-08-15
  
  www.siggraph.org/s2008/
Review: Parallelism

- Above the line (inter-computer, many machines) & below the line (intra-computer, multiple cores & CPUs) both critical for future.
  - Hard to write code that fully takes advantage of all available resources to get optimal speedup.
    - Amdahl’s Law: MaxSpeedup = 1/s (s = % of serial code)
  - Inter-computing Illism: Distributed & Supercomputing
    - Grid (usu remote, heterogeneous) & Cluster computing
    - Synchronization hard, APIs help (MapReduce, MPI)
  - Intra-computing Illism: pthreads, OpenMP
    - Cache coherence makes it difficult! Manycore, not multicore!
- Berkeley EECS & PAR lab taking initiative to make 1000+ core HW, put in researchers hands!
We learned about “Machine Structures”

Coordination of many *levels (layers) of abstraction*

- Processor
- Memory
- I/O system
- Datapath & Control
- Digital Design
- Circuit Design
- transistors

Software

- Application (ex: browser)
- Compiler
- Assembler

Operating System

System (Mac OS X)

Instruction Set Architecture

Hardware
We made HW/SW contact!

High Level Language Program (e.g., C)

Assembly Language Program (e.g., MIPS)

Machine Language Program (MIPS)

Compiler

Assembler

Machine Interpretation

Hardware Architecture Description (e.g., block diagrams)

Architecture Implementation

Logic Circuit Description (Circuit Schematic)

temp = v[k];

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

v[k+1] = temp;

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
CS61C: So what did you learn? (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 memory hierarchy (caches)
- Benefits of a layer of indirection (VM)
- Greater performance by exploiting parallelism
  - Pipelining, superscaler, ILP, MPI, MapReduce, OpenMP, pthreads

Principles/Pitfalls of Performance Measurement
Life: So what did you learn? (all yr)

- Use ISO 8601
  - YYYY-MM-DD

- Don’t be afraid
  - …to ask questions, sit in front, dance in the aisles

- Find your partner
  - Find the Yin to your Yang (project & life partners)

- Enjoy your youth
  - E.g., Travel while you aren’t tied down in your life

- Love your job
  - Love what you do; do what you love
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!!

- Implications for applications:
  - Computing power >>> CDC6600, Cray XMP (choose your favorite supercomputer) 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!
## Upcoming Calendar

<table>
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<th>Week #</th>
<th>Mon</th>
<th>Wed</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>#17 This week</td>
<td><strong>LAST CLASS</strong>&lt;br&gt;Summary, Review, &amp; HKN Evals&lt;br&gt;Performance comp due @ 11:59pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#18 FINAL REVIEW</td>
<td><strong>FINAL EXAM 5-8pm @ 1 Pimentel</strong>&lt;br&gt;Only bring pen(s), two 8.5”x11” handwritten sheets + green sheet.&lt;br&gt;Leave backpacks, books, calculators, cells &amp; pagers home!&lt;br&gt;Everyone must take ALL of the final!</td>
<td></td>
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</tbody>
</table>

Sun @ 2-5pm<br>10 Evans

---

![Map of University of California, Berkeley](https://via.placeholder.com/150)

CS61C L43 Summary & Goodbye (10)

Garcia, Spring 2008 © UCB
Administrivia: Become active!

- If you did well in CS3 or 61[ABC] (A- or above) and want to be on staff?
  - Usual path: Lab Assistant ⇒ Reader ⇒ TA
  - Contact Jenny Jones in 395 Soda before first week of semester for LA signup…
  - Reader/TA forms: www.cs/~juliea/
  - I strongly encourage anyone who gets an A- or above in the class to follow this path…
    - I’ll be teaching CS61C in 2009Sp. Why?
Survey Results

What is your feeling about what should be taught in the Spring of 2009?

- Lecture: 133
- Lab: 18
- Either is ok: 22
Survey Results

The amount of active learning is...

- Not enough: 66
- Just Right: 86
- Too much: 22
Survey Results

Do you own a CPS?

<table>
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<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>144</td>
<td>28</td>
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</tbody>
</table>
Survey Results

Is CPS worth it given the price?

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<th>Count</th>
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<tbody>
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<td>Yes</td>
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<tr>
<td>No</td>
<td>82</td>
</tr>
<tr>
<td>Neutral</td>
<td>48</td>
</tr>
</tbody>
</table>
Survey Results

Is CPS worth the class time?

- Yes: 126
- No: 21
- Neutral: 25
Survey Results

I prefer midterms solved...

By students
By the instructor
In discussion
Survey Results

How often do you attend lecture?

- Never: 0
- Rarely: 10
- Often: 97
- Always: 67
Survey Results

And by "attend", I mean...

- 2050 VLSB: 161
- Live Webcase: 2
- Later Webcast: 10
- N/A: 1
Survey Results

How many lectures have you watched on webcast?

- Every: 3
- Most: 16
- Some: 124
- None: 31
Survey Results

If it weren't for webcasts, I would attend lecture in VLSB...

- Much more
- Some more
- A little more
- The same

Survey Results

0 10 20 30 40 50 60 70 80 90
Survey Results

A webcast lecture archive would be...

- Very Useful: 60
- Moderately Useful: 70
- Somewhat Useful: 50
- Not Useful: 10
Survey Results

Most & Least Favorite Labs

Polling & I/O

Logisim Intro

FSM

Caches

Most Favorite

Least Favorite

0 10 20 30 40 50 60 70 80 90 100 110 120

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Survey Results

Project 1: Adventure Game

- Difficulty
- Relevance
- Enjoyment

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>

Garcia, Spring 2008 © UCB
Survey Results

Project 2: Eval Trees and Float

Difficulty
Relevance
Enjoyment
Survey Results

Project 3: CPU Design

- Difficulty
- Relevance
- Enjoyment

- Chart showing survey results for Project 3: CPU Design.
Survey Results

Project 4: Cache Simulator

Difficulty  Relevance  Enjoyment

0  10  20  30  40  50  60  70  80  90  100

1  2  3  4  5  6  7  8  9  10
Taking advantage of Cal Opportunities

“The Godfather answers all of life’s questions”
- Heard in “You’ve got Mail”

- Why were we the #2 Univ in the WORLD?
  - 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 2008

- **GamesCrafters** *(Game Theory R & D)*
  - Develop SW, analysis on 2-person games of no chance. (e.g., go, chess, connect-4, nim, etc.)
  - Req: ≥ A- in CS61C, Game Theory / SW Interest

- **MS-DOS X** *(Mac Student Developers)*
  - Learn to program Macintoshes.
  - Req: Interest. Owning a mac helps, not required.
  - Taught as a DeCal by MS-DOS X veterans

- **UCBUGG** *(Recreational Graphics)*
  - Develop computer-generated images, animations.
  - Req: 3D experience, portfolio
  - Taught as a DeCal by UCBUGG veterans
Strong or Weak AI?
**Strong AI:** Machines that act intelligently have real, conscious minds...sapience
**Weak AI:** Machines can be made to *act* as if they were intelligent, but won't be sapient.

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
Peer Instruction Answer

- Star Trek’s Data will exist. Strong AI!
- “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, aka wet computing.” – Dan Garcia
  - A macaque monkey at Duke University can already control a robotic arm with thought.
    - In 2005, EECS hired Prof Jose Carmena, a “wet computing” ace!
  - DARPA interested for mind-control robots & flying
  - Virtual Reality achieved with proper I/O interfacing…

[Link to source]

www.popsci.com/popsci/medicine/article/0,12543,576464,00.html
Penultimate slide: Thanks to the staff!

- **TAs**
  - Head TA David Jacobs
  - Omar Akkawi
  - Matt Johnson
  - Keaton Mowery
  - Casey Rodarmor
  - Ben Sussman
  - Brian Zimmer

- **Readers**
  - Hongcheng Chang
  - Timothy Wu
  - Andrew Toulouse
  - James Liao

- **TAs-in-Training**
  - Andrew Toulouse
  - James Liao
  - George Chen

Thanks to all the former CS61C instructors who have added to these notes…
The Future for Future Cal Alumni

- What’s The Future?
- New Millennium
  - Ubiquitous & Quantum Computing, Nanotechnology, 10 M “volunteer” CPUs, the Parallel revolution...
  - Rapid Changes in Technology
  - World’s 2nd Best Education
  - Never Give Up!

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

The Future is up to you!