The Challenge of the Multicores

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Topics

- The Multicore Challenge
- Meeting the Multicore Challenge
- Closing Remarks and Challenges
What Is The Challenge and Why Does It Matter?

- Computers are hitting a performance limit!

- “The biggest problem Computer Science has ever faced.” John Hennessy
An Idealized Supercomputer

- 1,000,000 processors
- 32,768 chips
- 512 boards

1 Gigaflop (32 processors)
16 Teraflops
2 Teraflops
32 Gigaflops
1 Petaflop

chip (32 processors)
board (64 chips)
cabinet (8 boards)
(8x8 cabinets)
A Problem

- Transistors continue to shrink
- More and more transistors fit on a chip
- The chips run faster and faster
- Resulting in HOT CHIPS!
Transistor Performance Stops Growing as Fast

Performance (GOPS)


1000 100 10 1 0.1 0.01

Gap

Transistors

Real Performance
Solution: Multicores and Software Parallelism??

- Simpler, slower, cooler processors (multicores)
- More processors on a chip
- Software (and users) organize tasks to execute in parallel on the processors
- Parallelism will provide the performance!
2007 Multicore Predictions ala Moore’s Law

- The number of cores will double every 18 - 24 months
  - 2007 - 8 cores on a chip
  - 2009 - 16 cores
  - 2013 - 64 cores
  - 2015 - 128 cores
  - 2021 - 1k cores

- Real Performance will Scale with the number of cores????
Parallelism is the new challenge

- High performance computing applications and computers have long used parallelism for performance.

- Current software cannot provide the parallelism needed

- Users can’t either
A Deeper View of the Multicore Challenge

The 15B transistor chip will be feasible in 10-12 years!!

1. What will the computer architecture look like?
2. Can users enable code for the new parallel systems?
3. Can automatic parallelizing compilers deliver the parallel performance inherent in the problem solution?
4. Do we need new languages, new computational models, radically different compilers and software stacks?
5. Are new data management optimizations the low hanging fruit?
Topics

- The Multicore Challenge
- Meeting the Multicore Challenge
- Final Comments and Challenges
Software and CS Recommendations:

- Automatic parallelism and optimization
- Very high level, domain specific languages
- Eliminate C, JAVA.... as general purpose languages
- Automatic and dynamic optimization of data locality, movement, organization, ownership, ....
- New formal models of parallelism
- Recast compilers
Hardware and Systems Recommendations

- Influence the architects
  - Keep the architecture simple
  - Eliminate caches

- Balance goals
  - User productivity
  - Application performance
  - System integrity

- Enable bold thinkers and high risk projects
Topics

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- Meeting the Multicore Challenge
- Final Comments and Challenges
The Hardware Solution to Parallelism!

The Parallel Hammer

We have defined the tool - it is up to you to figure out how to use it!
Strengthen Computer Science

- In a talk on “Understanding Science through the Lens of Computation”, Dick Karp said:
  - The algorithmic world view is changing the mathematical, natural, social, and life sciences.
  - Computer Science is placing itself at the center of scientific discourse and exchange of ideas. And this is only the beginning.

- **Computer Science: the Queen of the Sciences!**
Breaking News (HPC: March 4, 2010)

- 2009 Sandia study on key algorithms for deriving knowledge from large data sets running on multicores:
  - 2 - 4 cores ➔ significantly faster
  - 4 – 8 cores ➔ some increase
  - > 8 cores ➔ speed decreases
  - 16 cores ➔ barely as well as 2 cores
  - > 16 cores ➔ steep decline in speed

- New multicore processors are coming on the market

HOW FAST WILL YOUR PROGRAMS RUN?
Solve the Performance Challenge

- “The biggest problem Computer Science has ever faced.” John Hennessy

- “The best opportunity Computer Science has to improve user productivity, application performance, and system integrity.” Fran Allen
End Note

“The fastest way to succeed is to double your failure rate.” – T. J. Watson, Sr.
END OF TALK

START OF A NEW ERA IN COMPUTING AND COMPUTER SCIENCE!