The Challenge of the Multicores

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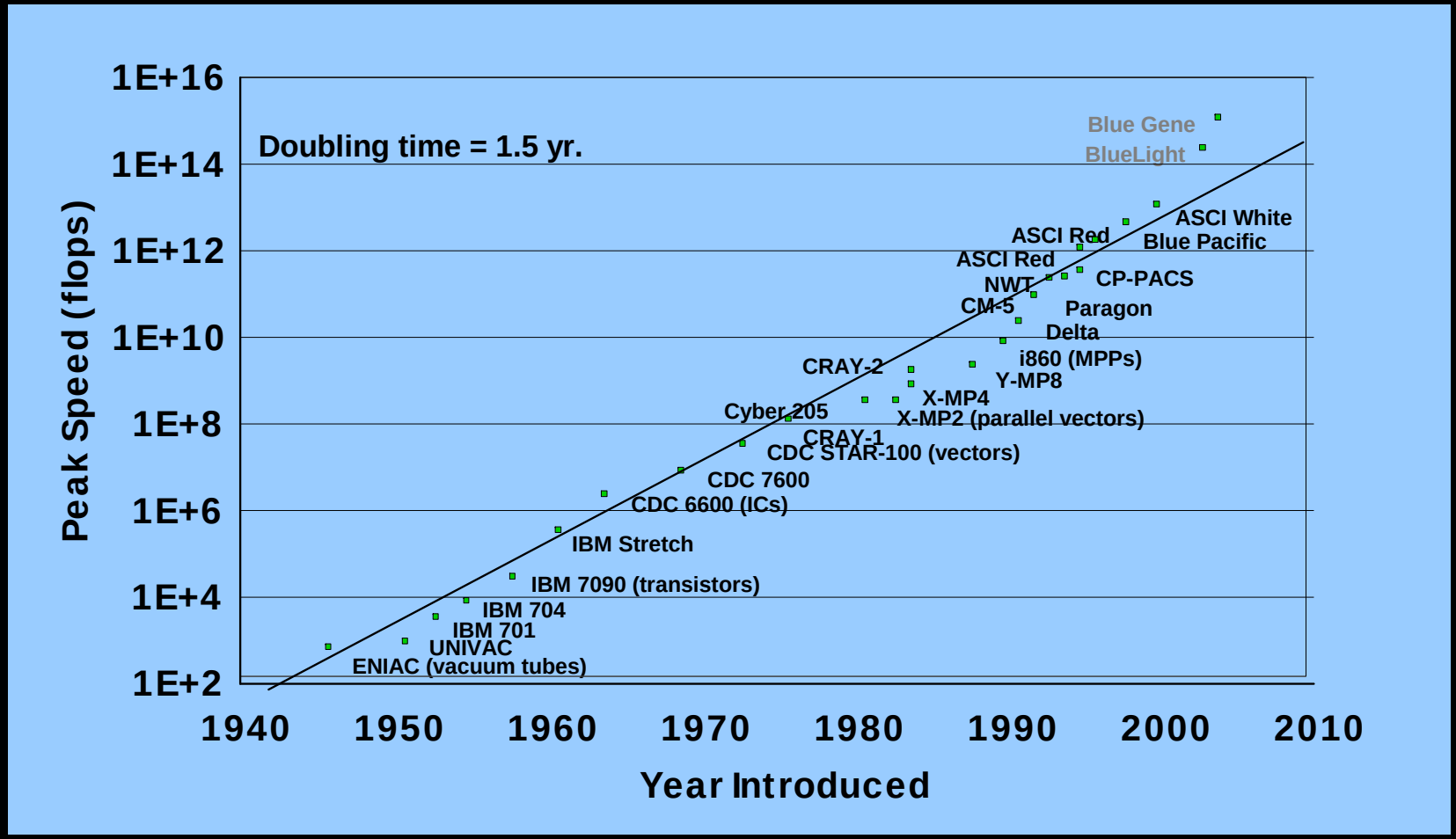
Topics

- The Multicore Challenge
- Meeting the Multicore Challenge
- Closing Remarks and Challenges

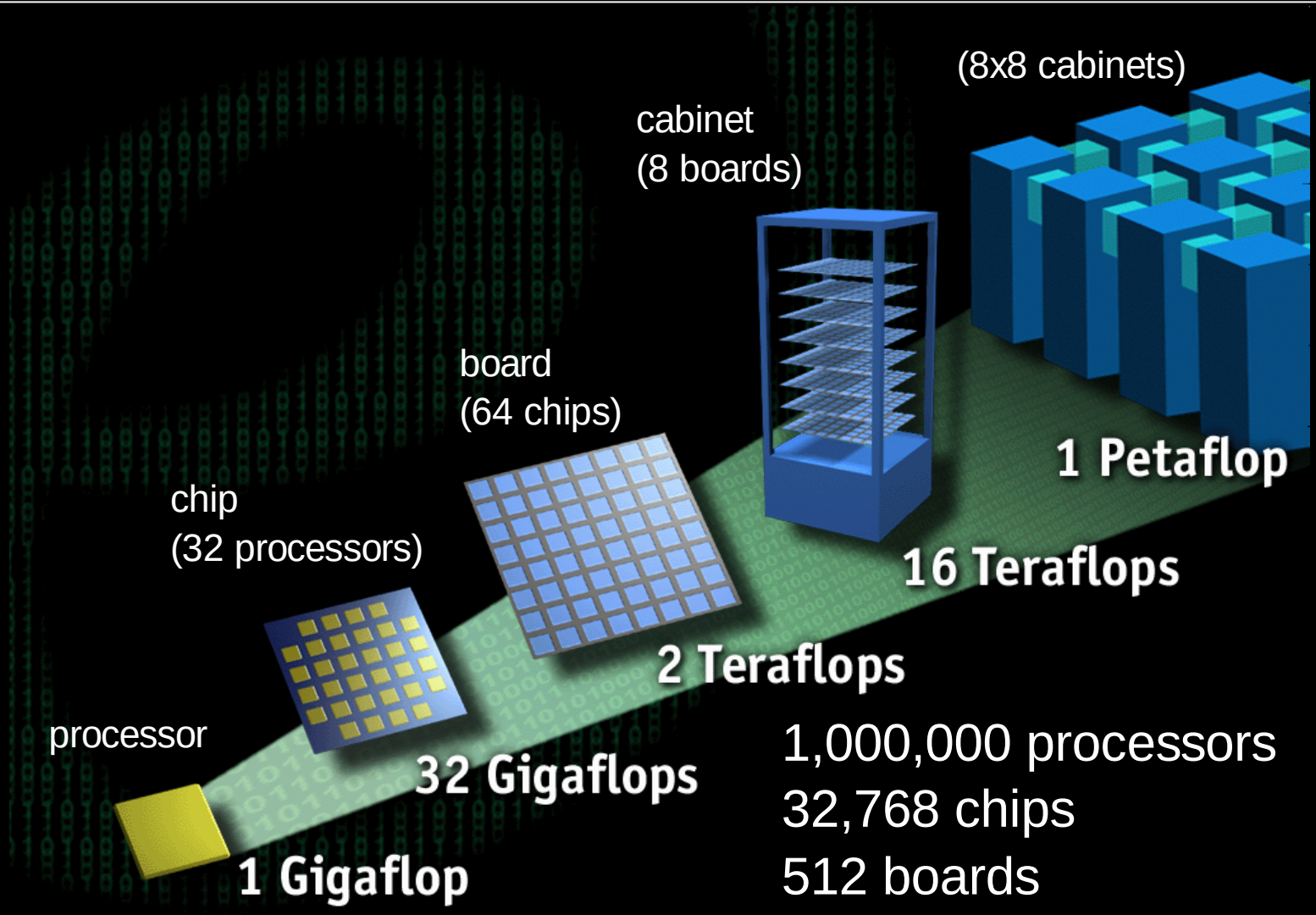
What Is The Challenge and Why Does It Matter?

- Computers are hitting a performance limit!
- “The biggest problem Computer Science has ever faced.” John Hennessy

Peak Performance Computers by Year



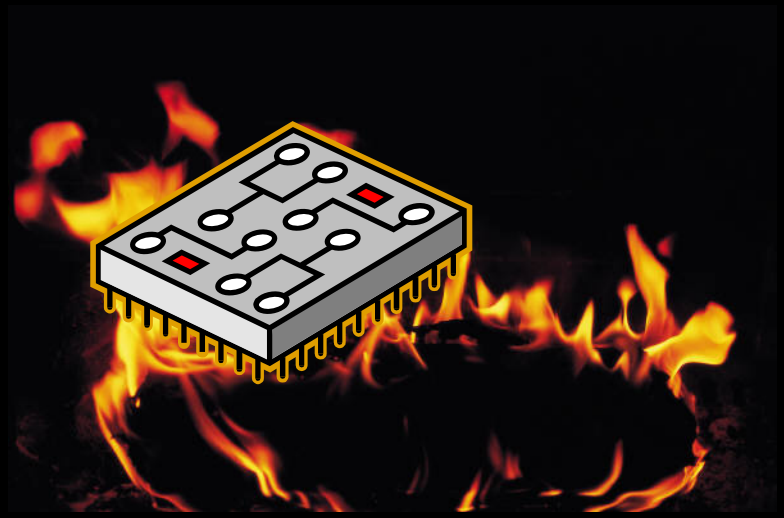
An Idealized Supercomputer



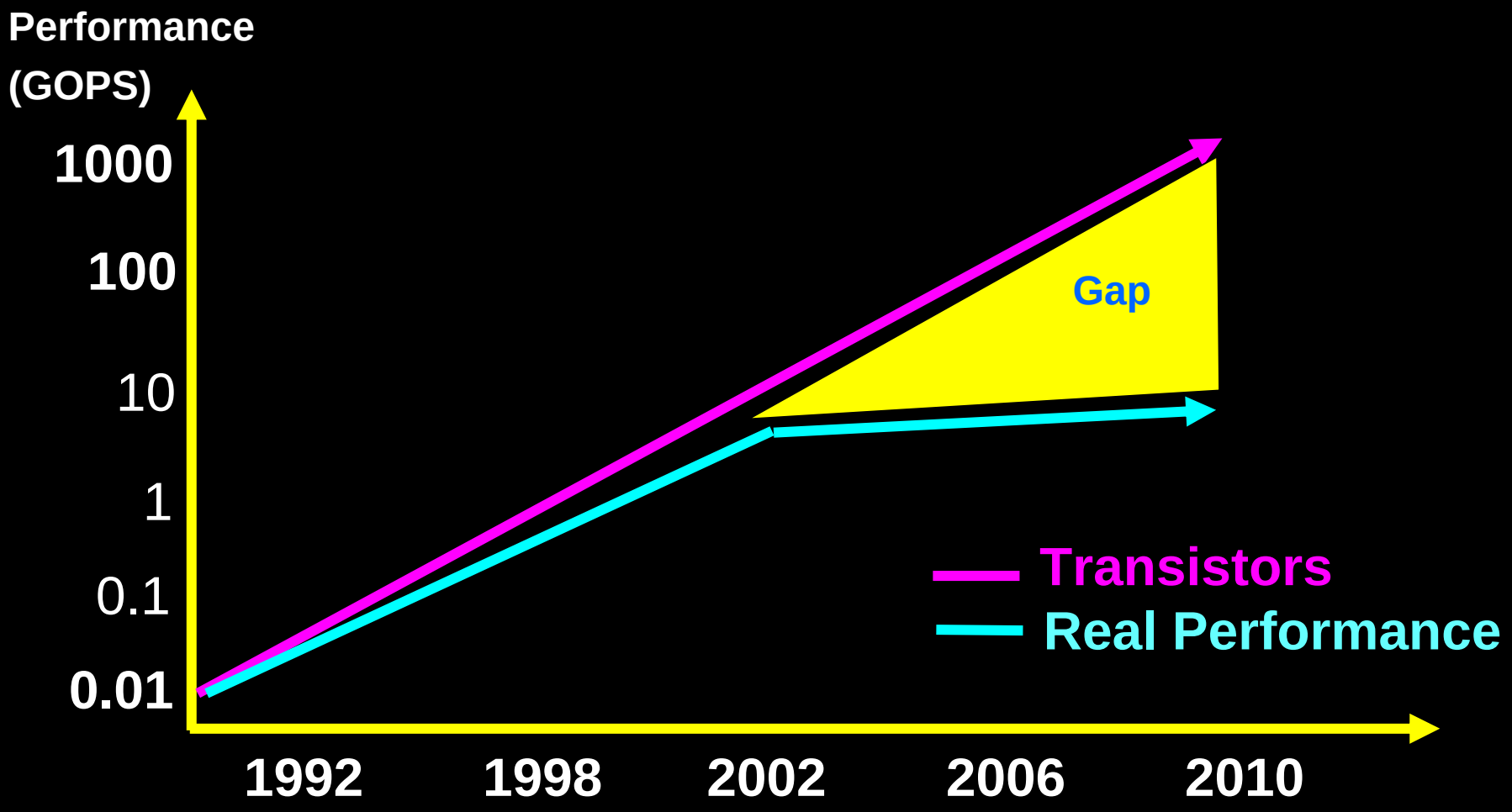
1,000,000 processors
32,768 chips
512 boards

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



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

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- 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

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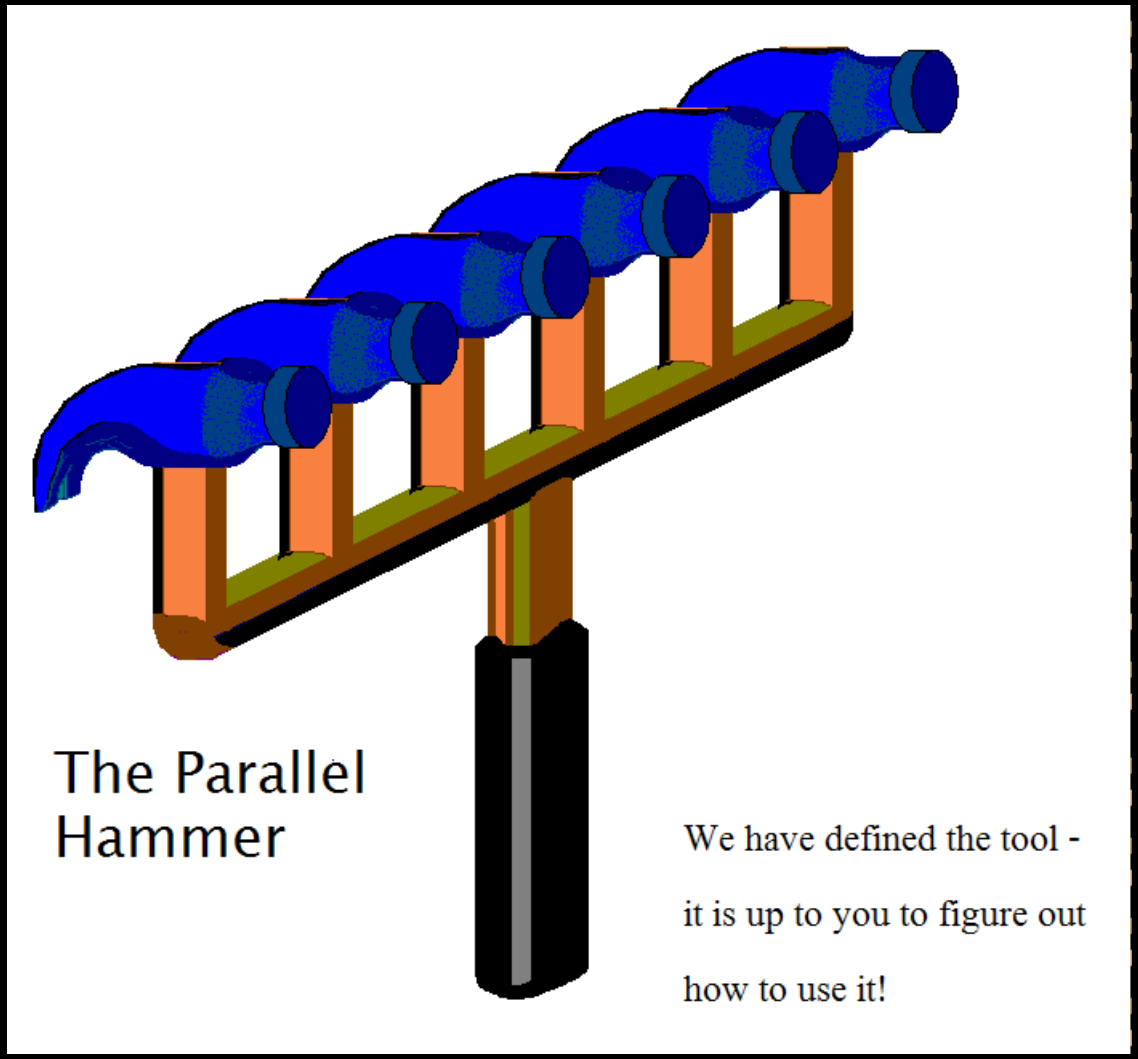
The Hardware Solution to Parallelism!



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!