

Tools for the Multi-Processor Computing Framework

Algorithms and Parallel Software Workshop

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ParaTools, SAS, ParaTools, Inc. and University of Oregon

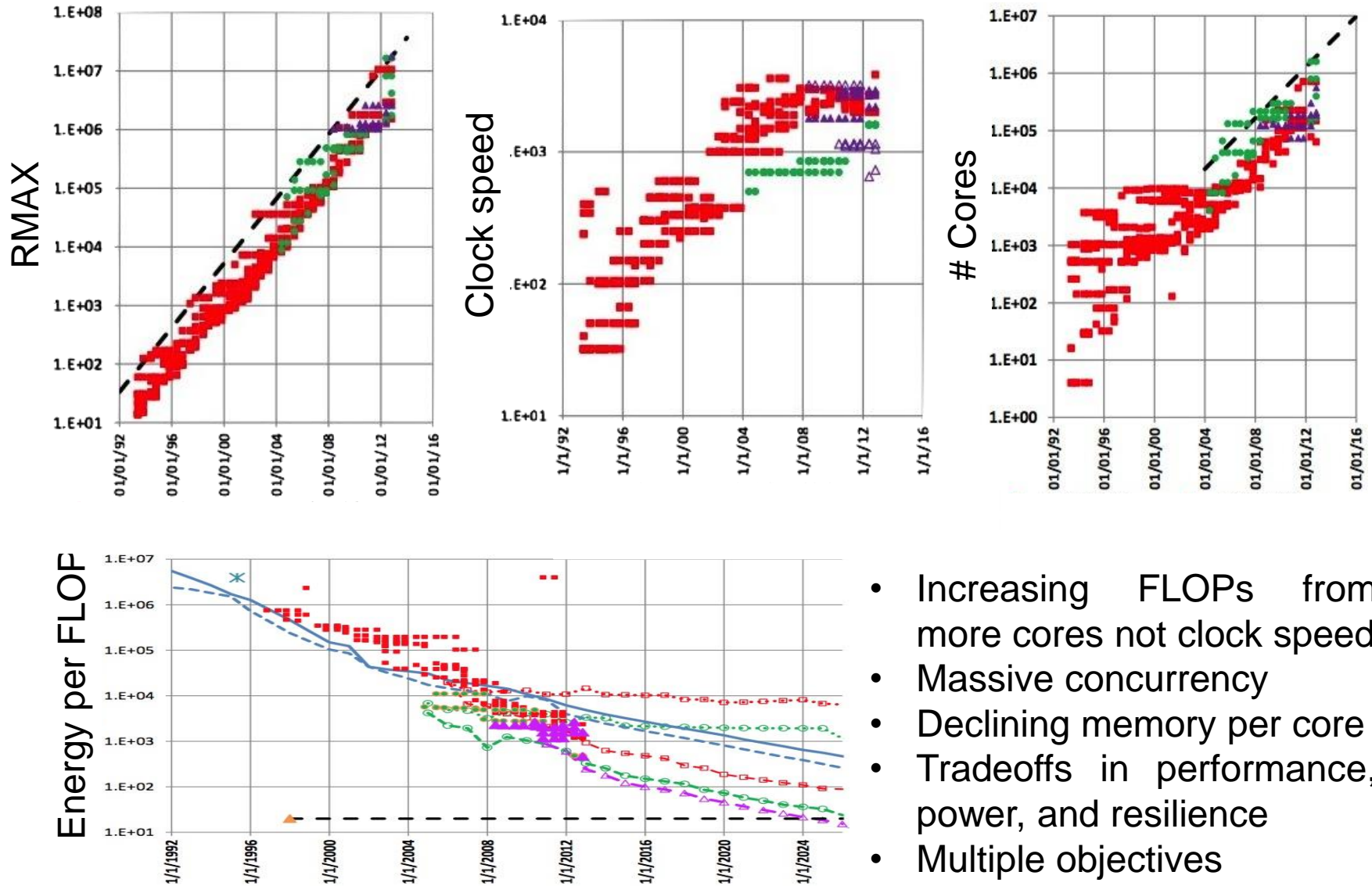
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A Steady Evolution of HPC

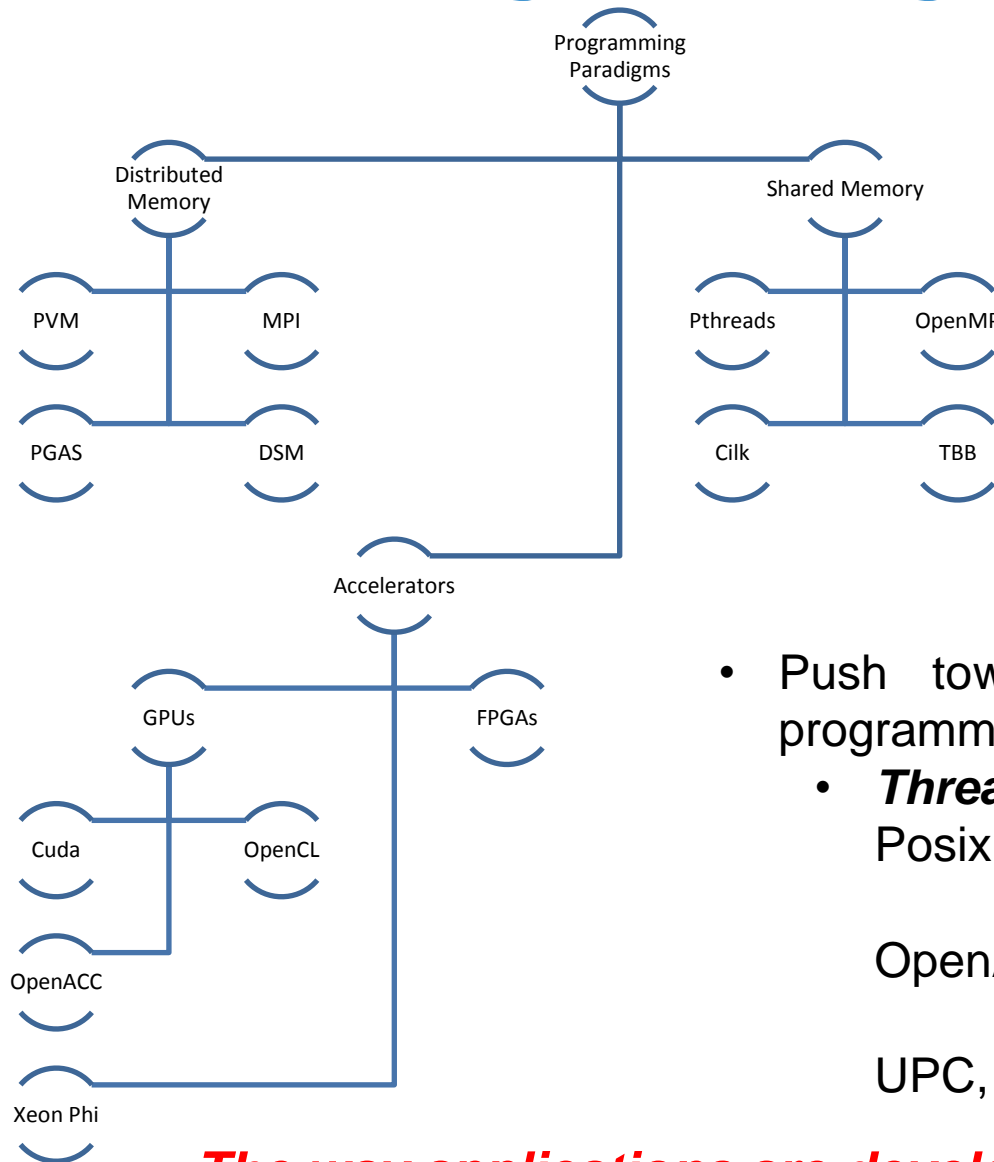
- HPC has driven the progress in science and engineering
- HPC is now seen as the key determinant in R&D processes, scientific productivity, and global security
 - It is the basis of industrial and research competitiveness
 - It is fundamentally shaping the future of computing and addressing humankind's greatest problems
- HPC systems are evolving at a rapid pace, producing unique computing capabilities and performance potential
- **However, performance complexity is also increasing**

Trends for HPC Hardware



- Increasing FLOPs from more cores not clock speed
- Massive concurrency
- Declining memory per core
- Tradeoffs in performance, power, and resilience
- Multiple objectives

Parallel Programming Dilemma



- HPC developers are facing a wide range of programming model and computing substrates
- Applications are more complex and modeling important phenomena
- Evolutionary trends require more complex programming technology

- Push towards *mixed-mode* parallel programming model (MPI + X)

- **Thread parallelism:**

- Posix, OpenMP, TBB / Cilk

- **Accelerator:**

- OpenACC, CUDA, OpenCL

- **PGAS:**

- UPC, Co-Array Fortran, Chapel

The way applications are developed will have to change

Mixed-mode Parallelisms Challenges

New parallel programming systems must be:

- Flexible and efficient, easy to use, scalable
- With unified runtime support (scheduling, communication, memory)
- Must include performance and debugging tool support

Mixed-mode parallel development environment are not well-integrated

- Mismatch of programming methodology
- Clash of programming model implementation and tools

MPC is a powerful approach to addressing these challenges

- Most advanced thread-based MPI implementation
- Featuring OpenMP support on an unified scheduler
- Being extended to support accelerators and other models (TBB)
- Supported by most compilers including Intel ICC
- **Still need debugger and profiling tools support**

ParaTools and MPC

ParaTools

ParaTools is an expert consulting company in HPC

Profiling and optimization of HPC applications

- Performance analysis of HPC application codes
- Parallelization and tuning of applications to new architectures
- Developers of the TAU Performance System[®]

HPC Software development

- Creation of innovative HPC solutions
 - IO, Network, Big Data
- Integration with HPC middleware
 - Compiler, runtime, monitoring tools
- Design of domain specific languages (DSL) for HPC
- Development of numerical modeling environments

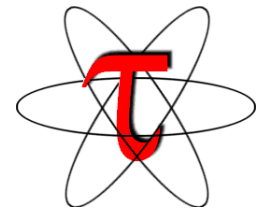
ParaTools in the World



MPC Enhancements

- ParaTools is working in collaboration with the CEA to develop and extend the MPC runtime
- We are supporting the MPC ecosystem
 - Host the MPC website
- We are promoting MPC
 - During our consulting work to our clients
 - During workshops
 - At the next MPI forum
- We write research papers around MPC's features
- **We are integrating MPC support in our profiling tools**
 - **TAU Performance System is being ported to MPC**

TAU Performance System[®]



- **Tuning and Analysis Utilities (20+ year project)**
- **Comprehensive performance profiling and tracing**
 - Integrated, scalable, flexible, portable
 - Targets all parallel programming/execution paradigms
- **Integrated performance toolkit**
 - Instrumentation, measurement, analysis, visualization
 - Widely-ported performance profiling / tracing system
 - Performance data management and data mining
 - Open source (BSD-style license)
- **MPC development**
 - MPI-only mode
 - MPI + OpenMP mode (using the OMPT interface)

Conclusion

- Efficiently using next generation machines WILL require important code evolutions to shift to MPI+X
- MPC is an important and powerful step in this transition
 - Allowing MPI tasks to run as threads
 - Fairly mixing programming models
- MPC retains the value of production code (millions of lines) with automatic and progressive porting to MPI+X
 - Support for common programming models with unified scheduler
 - Automatic privatization of global variables at compiler level
- **ParaTools will include performance tool support for MPC**