IBM ACTC: Helping to Make Supercomputing Easier

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IBM Research

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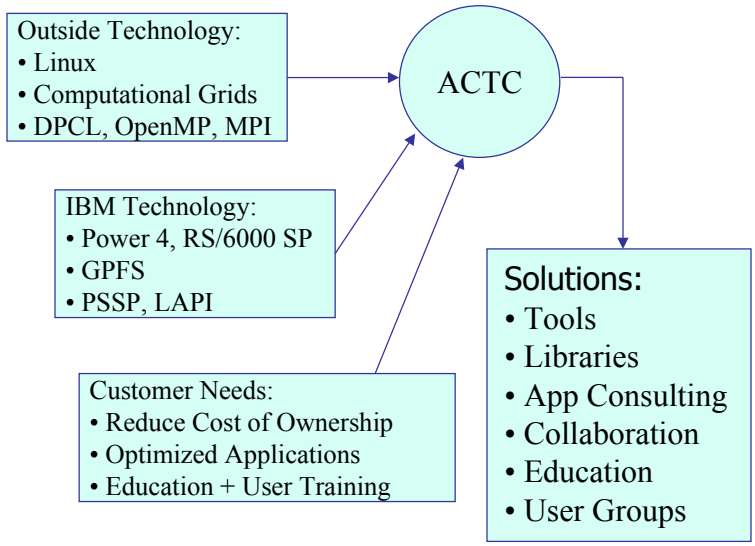
Outline

- Who we are
  - Mission statement
  - Functional overview and organization
  - History
- What we do
  - Industry solutions and activities
    - Education and training
    - STC community building
    - Application consulting
    - Performance tools research

ACTC

- Mission
  - To close the gap between HPC users and IBM
  - Conduct research on applications for IBM servers within the scientific and technical community
    - Technical directions
    - Emerging technologies
- ACTC - Research
  - Software tools and libraries
  - HPC applications
  - Research collaborations
  - Education and training
- Focus
  - AIX and Linux platforms

ACTC Functional Overview



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ACTC History

- Created in September, 1998
  - Emphasis on helping new customers to port and optimize on IBM system
  - Required establishing relationships with scientists on research level
- Expanded operations via alignment with Web/Server Division:
  - EMEA extended in April, 1999
  - AP extended (TRL) in September, 2000
  - Partnership with IBM Centers of Competency (Server Group)

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ACTC Education

- 1st Power4 Workshop
  - Jan. 24,25, 2001 at Watson Research
  - Full Architecture Disclosure from Austin
- 1st Linux Clusters Optimization Workshop
  - May 25--27, 2001 at MHPCC
  - Application Tuning for IA32 and Myrinet
- 2001 European ACTC Workshop on IBM SP
  - Feb. 19,20, 2001 in Trieste (Cineca)
  - http://www.cineca.it/actc-workshop/index.html
- 2001 Japan HPC Forum and ACTC Workshop
  - July 17--19 2001 in Tokyo and Osaka
- 1st Linux Clusters Institute Workshop
  - October 1--5, 2001 at UIUC/NCSA (Urbana)
- IBM Research Internships at Watson

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HPC Community: IBM ScicomP

- Established in 1999 via ACTC Workshop
- IBM External Customer Organization
  - Equivalent to "CUG" (Cray User Group)
- 2000 – US and European groups merge
- 2001
  - 1st European Meeting (SciComp 3)
    - May 8-11, Barcelona, Spain (CEPBA)
  - US Meeting: October 9-12, Knoxville, TN
- 2002 -
  - ScicomP 5, Manchester, England (Daresbury Lab)
  - ScicomP 6, Berkeley, CA (NERSC)
    - Joint meeting with SP/XXL
- 2003 -
  - ScicomP 7 in Goettingen, Germany, March 3-7
  - ScicomP 8 in Minneapolis (MSI), August 5-9
- http://www.spscicomp.org

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HPC Community: LCI

- Linux Clusters Institute (LCI)
  - http://www.linuxclustersinstitute.org
  - Established April, 2001
  - ACTC Partnership with NCSA and HPCERC
  - Mission: education and training for deployment of Linux clusters in the STC community
  - Primary activity: intensive, hands-on workshops
  - Upcoming Workshops
    - Albuquerque, NM (HPCERC) Sep 30-Oct 04, 2002
    - University of Kentucky, Lexington - Jan 13-17, 2003
- The third LCI International Conference on Linux Clusters
  - October 23-25, 2002; St Petersburg, FL
  - http://www.linuxclustersinstitute.org/Linux-HPC-Revolution/

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Porting Example - NCSC (Cray)

- ACTC Workshop at NCSC
  - Bring your code and we show you how to port it (5-day course)
  - 32 researchers attended
  - All but one were ported by end of the week
    - the one code not ported was because it was written in PVM, and was not installed on the SP system
- NCSC now conducts their own workshops

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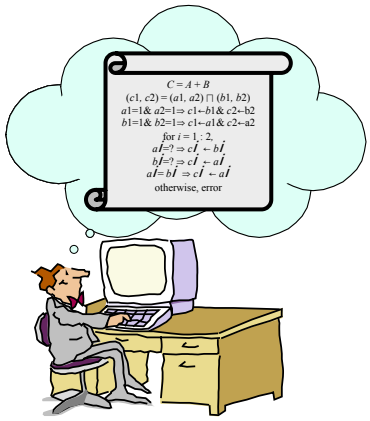
Porting Examples

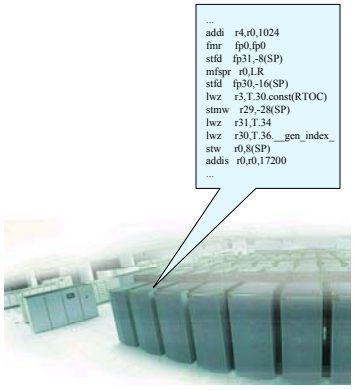
- NAVO (Cray)
  - Production benchmark code required maximum of 380-400 elapsed seconds
    - ACTC ported and tuned this code to run under 315 seconds on the SP
  - ACTC Workshop at NAVO
    - 8 production codes ported and optimized by end of week
- EPA (Cray)
  - One ACTC man-month
    - Convert largest user code to the SP
    - Codes now run 3 to 6 times faster than they did on T3E
- NASA/Goddard
  - 5 codes ported with help of one ACTC scientist working onsite for two weeks

HPC Tools Requirements

- User demands for performance tools
  - e.g., memory analysis tools, MPI and OpenMP tracing tools, system utilization tools
- Insufficient tools on IBM systems
  - Limited funding for development
  - Long testing cycle (18 months)
- STC Users comfortable with “AS-IS” software

Performance Tools Challenge





- User’s mental model of program do not match with executed version
  - Performance tools must be able to revert this semantic gap

ACTC Tools

- Goals
  - Help IBM sales in HPC and increase user satisfaction
  - Complement IBM application performance tools offerings
- Methodology
  - Development in-house and in collaboration with Universities and Research Labs
  - When available, use infrastructure under development by the IBM development divisions
  - Deployment "AS IS" to make it rapidly available to the user community
  - Close interaction with application developers for quick feedback, targeting functionality enhancements
- Focus
  - AIX and Linux

ACTC Software: Tools

- Performance Tools
  - HW Performance Monitor Toolkit (HPM)
    - HPMCount
    - LIBHPM
    - HPMViz
    - CATCH
  - UTE Gantt Chart
    - MPI trace visualization

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ACTC Software: Collaborative Tools

- OMP/OMPI trace and Paraver
  - Graphical user interface for performance analysis of OpenMP programs
  - Center for Parallelism of Barcelona (CEPBA) at UPC - Spain
- SvPablo
  - Performance Analysis and Visualization system
  - Dan Reed at University of Illinois
- Paradyn and Dyninst
  - Dynamic system for performance analysis
  - Bart Miller at University of Wisconsin
  - Jeff Hollingsworth at University of Maryland

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ACTC Software: Libraries

- MPItrace
  - Performance trace library for MPI analysis
- TurboMPI
  - Collective communication functions to enhance MPI performance for SMP nodes
- TurboSHMEM
  - "Complete" implementation of Cray SHMEM interface to allow easy and well-tuned porting of Cray applications to the IBM RS/6000 SP
- MIO (Modular I/O)
  - I/O prefetching and optimization library to enhance AIX Posix I/O handling

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Current Research Projects

- Hardware Performance Monitor (HPM) Toolkit
  - Data capture, analysis and presentation of hardware performance metrics for application and system data
    - Correlation of application behavior with hardware components
    - Hints for program optimization
    - Dynamic instrumentation and profiler
- Simulation Infrastructure to Guide Memory Analysis (SIGMA)
  - Data-centric tool under development to
    - Identify performance problems and inefficiencies caused by the data layout in the memory hierarchy
    - Propose solutions to improve performance in current and new architectures
    - Predict performance

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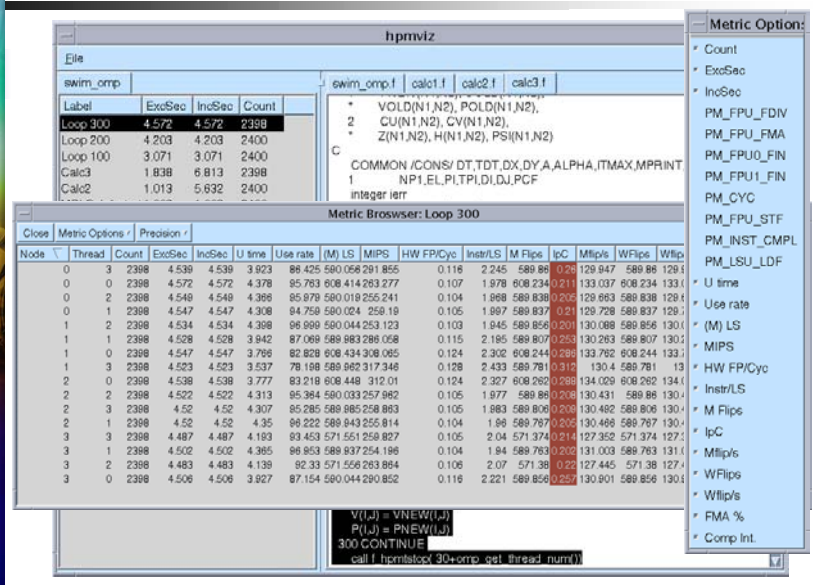
HPMVIZ



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SIGMA

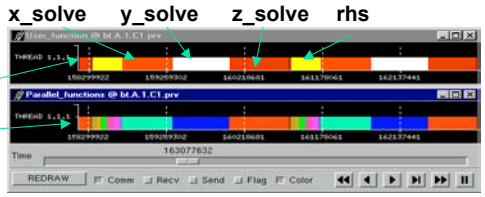
- Where is the memory?
- Motivation
  - Efficient utilization of the memory subsystem is a critical factor to obtain performance on current and future architectures
- Goals:
  - Identify bottlenecks, problems, and inefficiencies in a program due to the memory hierarchy
  - Support serial and parallel applications
  - Support present and future architectures

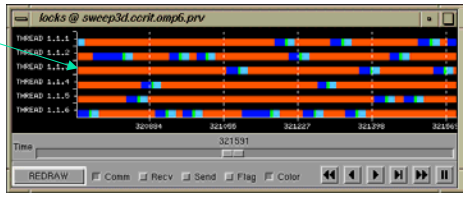
Current Collaboration Efforts

- LLNL (CASC) – with Jeff Vetter
  - Interpreting HW Counters analysis
    - Handling of large volume of multi-dimensional data
    - Correlate hardware events with performance bottlenecks
- Research Centre Juelich – with Bernd Mohr
  - Usability and reliability of performance data obtained from performance tools
  - Feasibility of automatic performance tools
- CEPBA (UPC) – with Jesus Labarta
  - Performance analysis of OpenMP programs
  - OMP/OMPI Trace & Paraver interface
- University of Karlsruhe - with Klaus Geers
  - HPM Collect

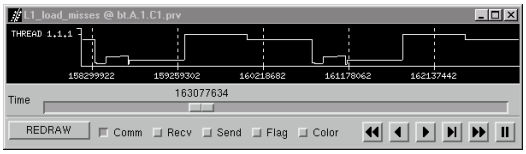
Program Analysis - Paraver

- Basics:
  - Functions
  - Loops
  - Locks



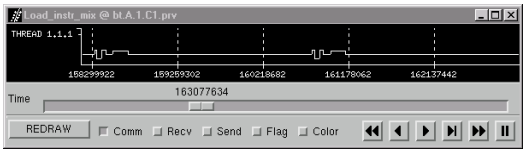


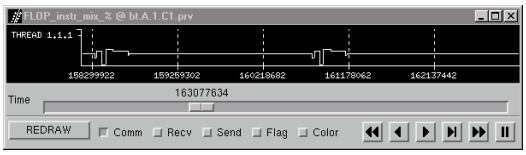
- Hardware counters:
  - TLB misses
  - L1 misses
  - …

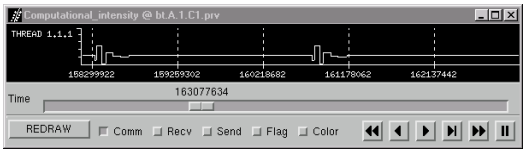


Hardware Counters Analysis

- Derived metrics
  - Instruction mix
    - %Loads
    - %Flops
  - Computational intensity
    - flops/loads
  - Program on architecture
    - miss ratios
    - FLOPS per L1 miss
  - Performance
    - IPC
    - FPC

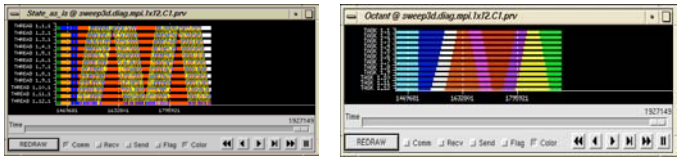




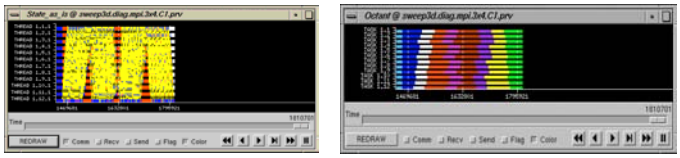


Analysis of Decomposition Effects

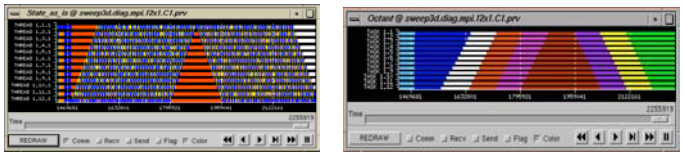
- 1 x 12



- 3 x 4



- 12 x 1



Summary

- ACTC is a consolidation of IBM's highest level of technical expertise in HPC
- ACTC research is rapidly disseminated to maximize benefits of IBM servers for HPC applications