IBM Research

Advanced Computing Technology Center Update

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ACTC Toolkit Activities

- **HPC Toolkit**
  - Traditional framework for interactive application performance analysis
  - Analysis-based as opposed to tuning-based
- **HPCS Toolkit (DARPA Productivity Program)**
  - Next generation framework for automated intelligent-assist of application performance tuning
  - Emphasis on Tuning
  - “Automated”…..not automatic.

IBM HPC Toolkit – Feature Highlights

- **One unified package (AIX, Linux/Power)**
  - One common visualization GUI
  - Simultaneous instrumentation for all tools (one run!)
  - Integrated tools for MPI, OMP, processor, memory etc
- **No alteration of source code required**
- **Interactive (GUI) or Programmable (Scriptable) interface**
- **Dynamically activate/deactivate data collection and change what information to collect**

IBM HPC Toolkit – New in 2007

- **Dynamic CPU profiling**
- **Redesigned MPI Profiler/Tracer component**
  - Dynamic MPI profiling capability
  - Support for MPI-IO in MPI profiling and tracing
- **Redesigned hardware counter library**
- **I/O Performance Profiling**
- **New “IDE” features in GUI**
  - binary instrumenter
  - File editing
  - Visual source line traceback
  - Job launcher
- **Support for more platforms - BG/P, 64 bit Linux**

Scalability Improvement – CPU profiling

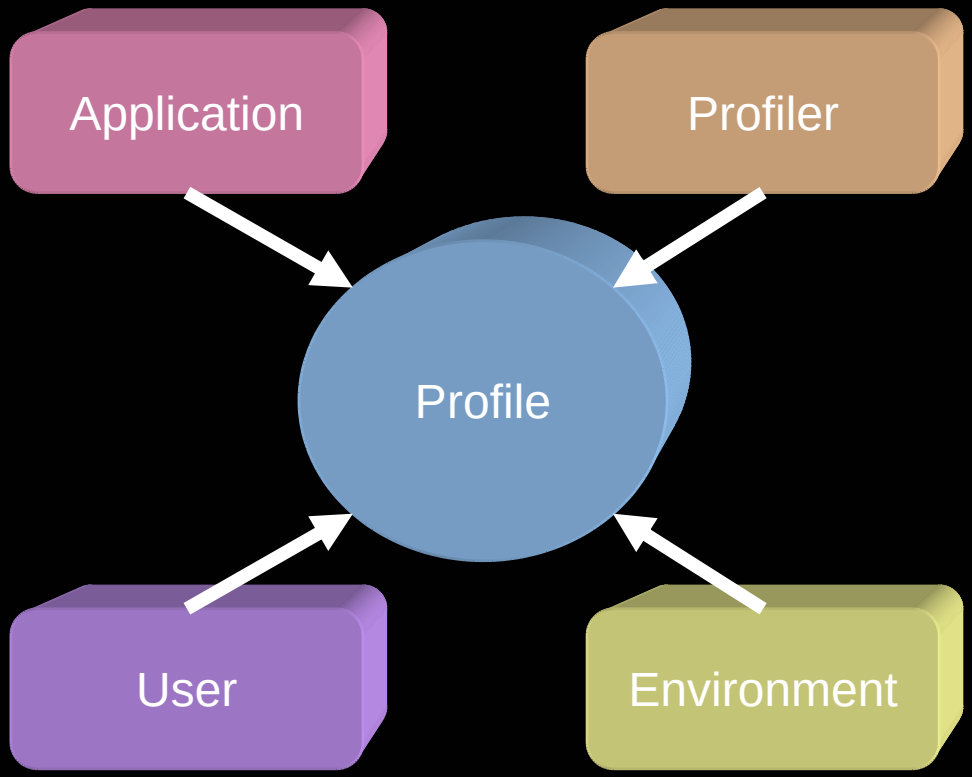
- **Based on binary rewriting**
- **Simulate gprof**
  - Intercept function calls
    - injects stack walking functions to gather call graph information
    - Use hash tables to record call graph info
  - Splice in the sampling function
    - At the start of the user code execution
  - Splice in the output generation function

Advantages of Improved CPU Profiler

- **Able to profile functions in precompiled libraries**
- **Avoid many of the dangling function calls in the call tree**
- **Especially useful for math libraries and MPI libraries.**

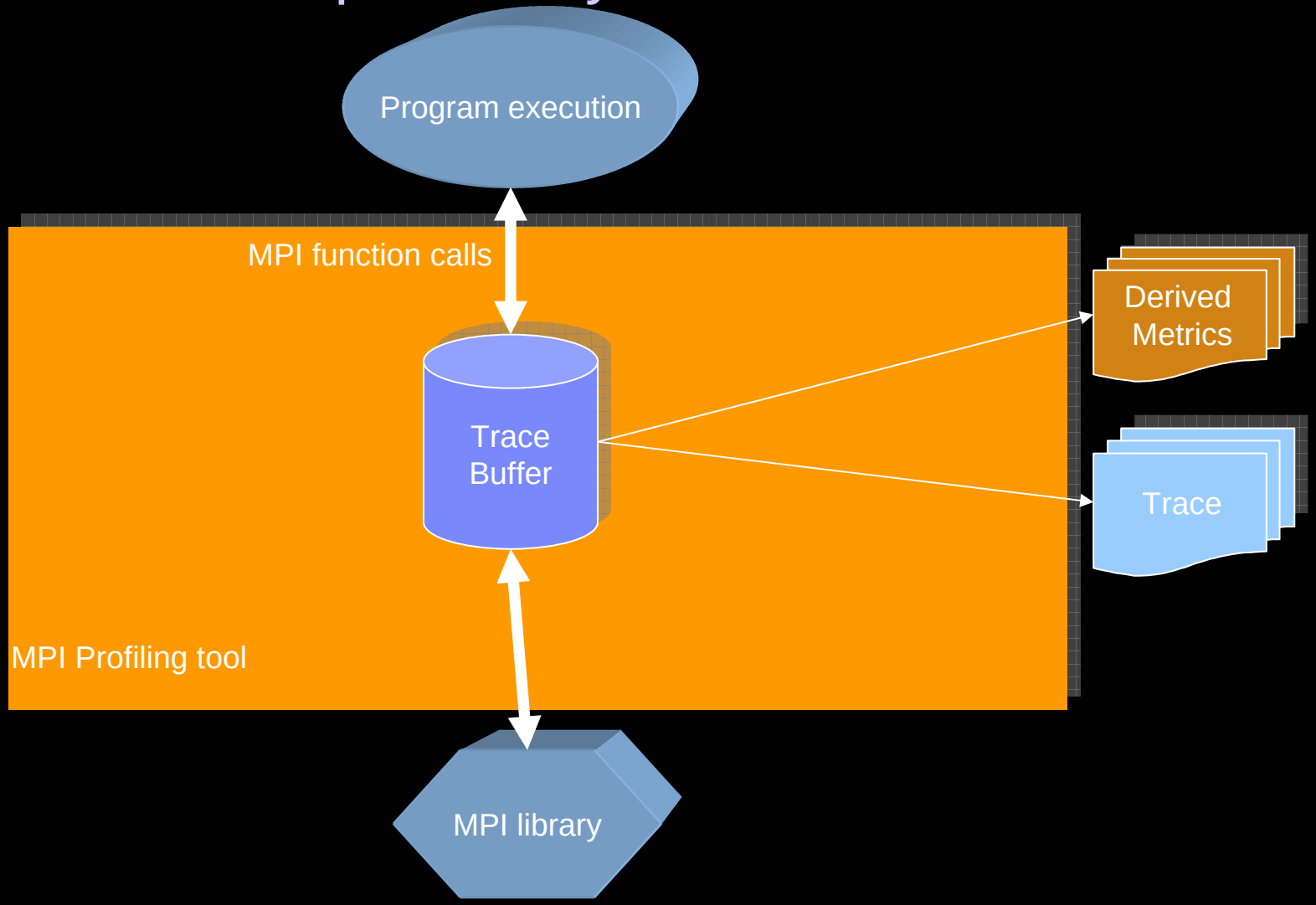
Scalability Improvement – Configurable MPI Profiling

- **Software specific info.**
  - Code segment
- **“Tool factor”**
  - Memory usage

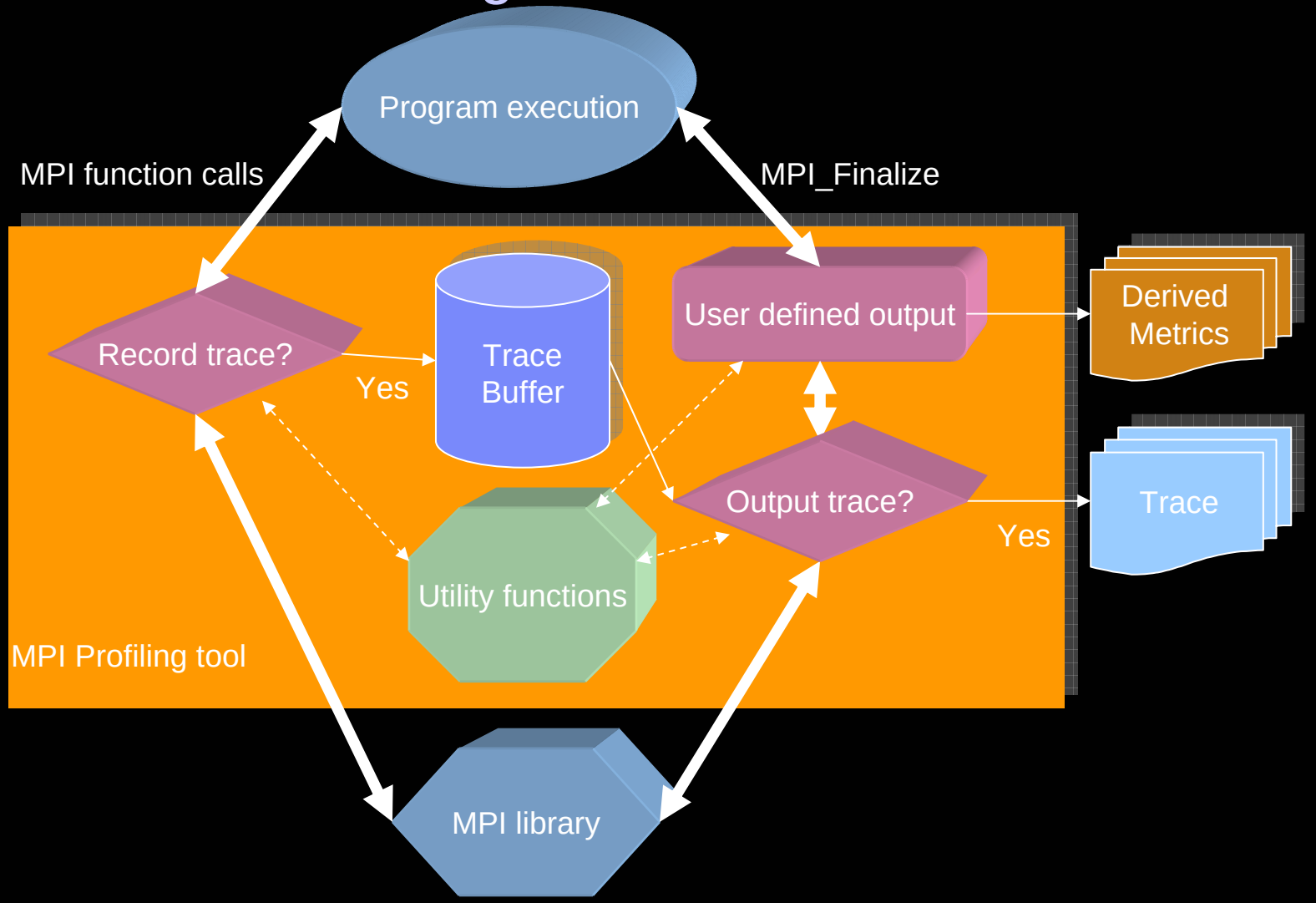


- **User preference**
  - User-defined metrics
- **System info.**
  - Node location

Implementation - previously



Implementation - Configurable



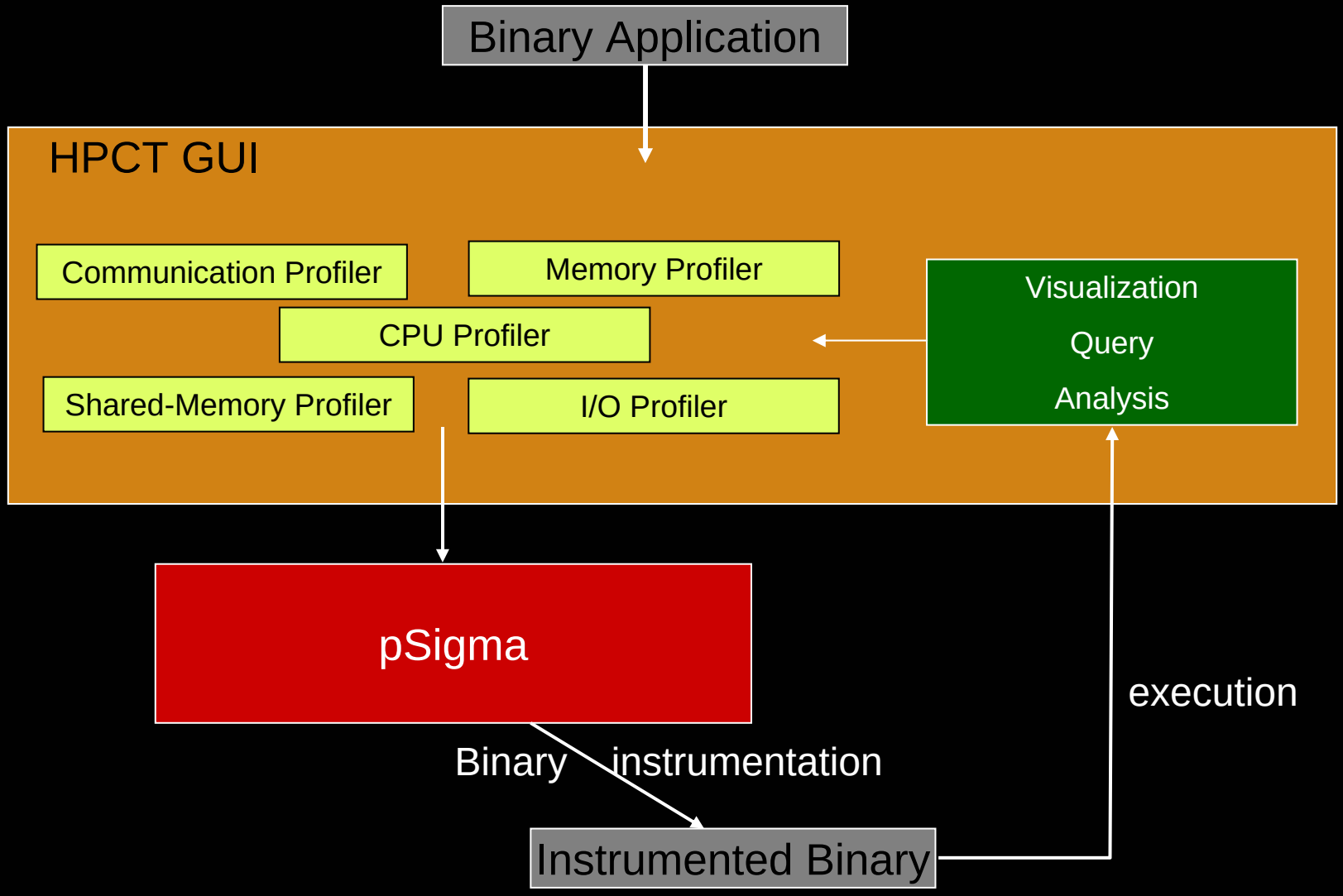
Update – Hardware Counter Monitoring

- **Generic executable/library**
  - One executable fits all (for Power[4,5,5+,6]/AIX)
  - Support more platforms
- **Nested loop no longer necessary**
  - Support partially overlapped instrumented code segment
- **Linux/Power**
  - Replace underlying perfctr layer with perfmon2

Update – Instrumentation Framework (pSigma)

- **IBM HPC is integrated into the pSigma infrastructure**
  - Symbolic/Binary instrumentation engine
- **Modularization**
  - Binary Analysis System
  - Binary Instrumentation System
- **Availability**
  - Supports 32/64 bit application on Linux/Power
  - Supports 32 bit application on AIX/Power

Structure of the IBM HPC toolkit



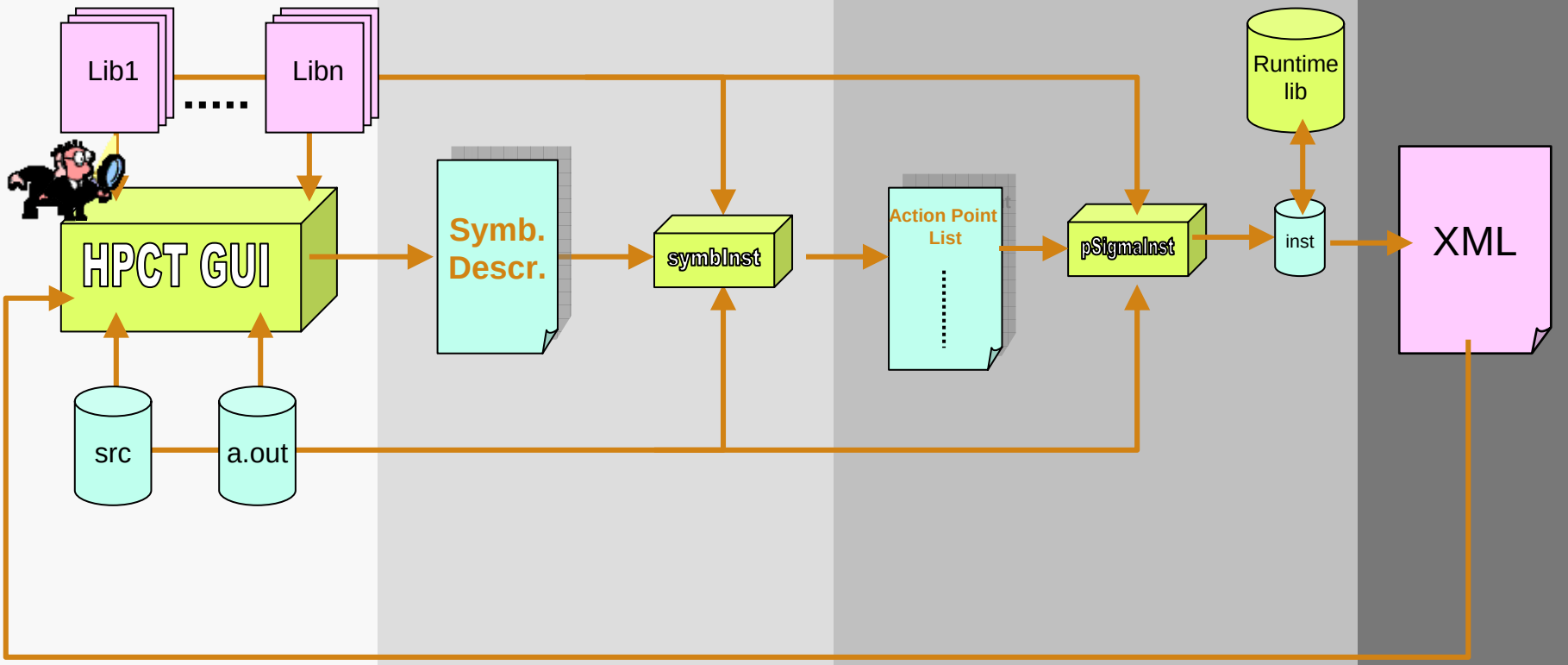
HPCT GUI: Graphical Instrumentation, Visualization and Analysis

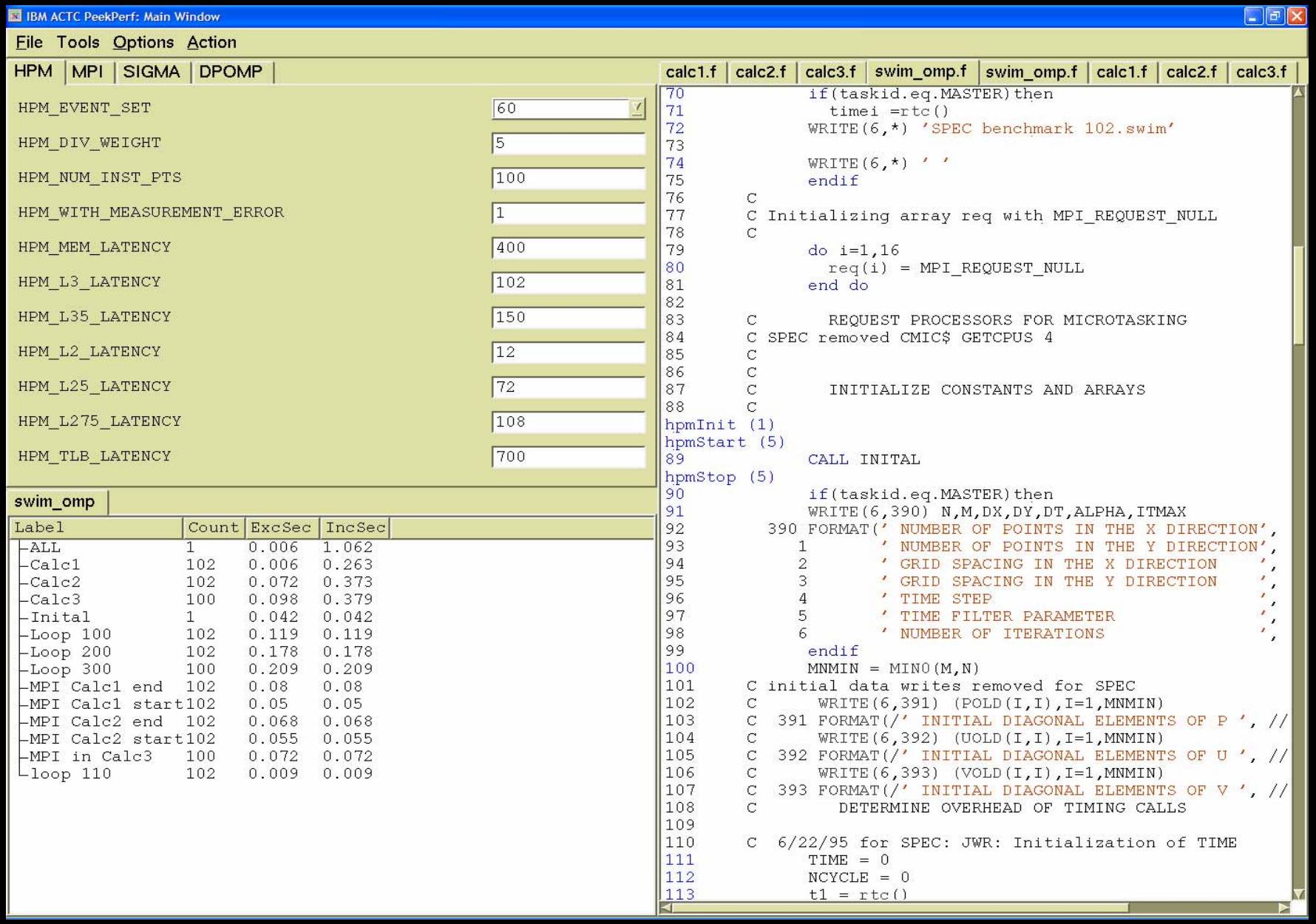
Instrumentation Visualization Analysis

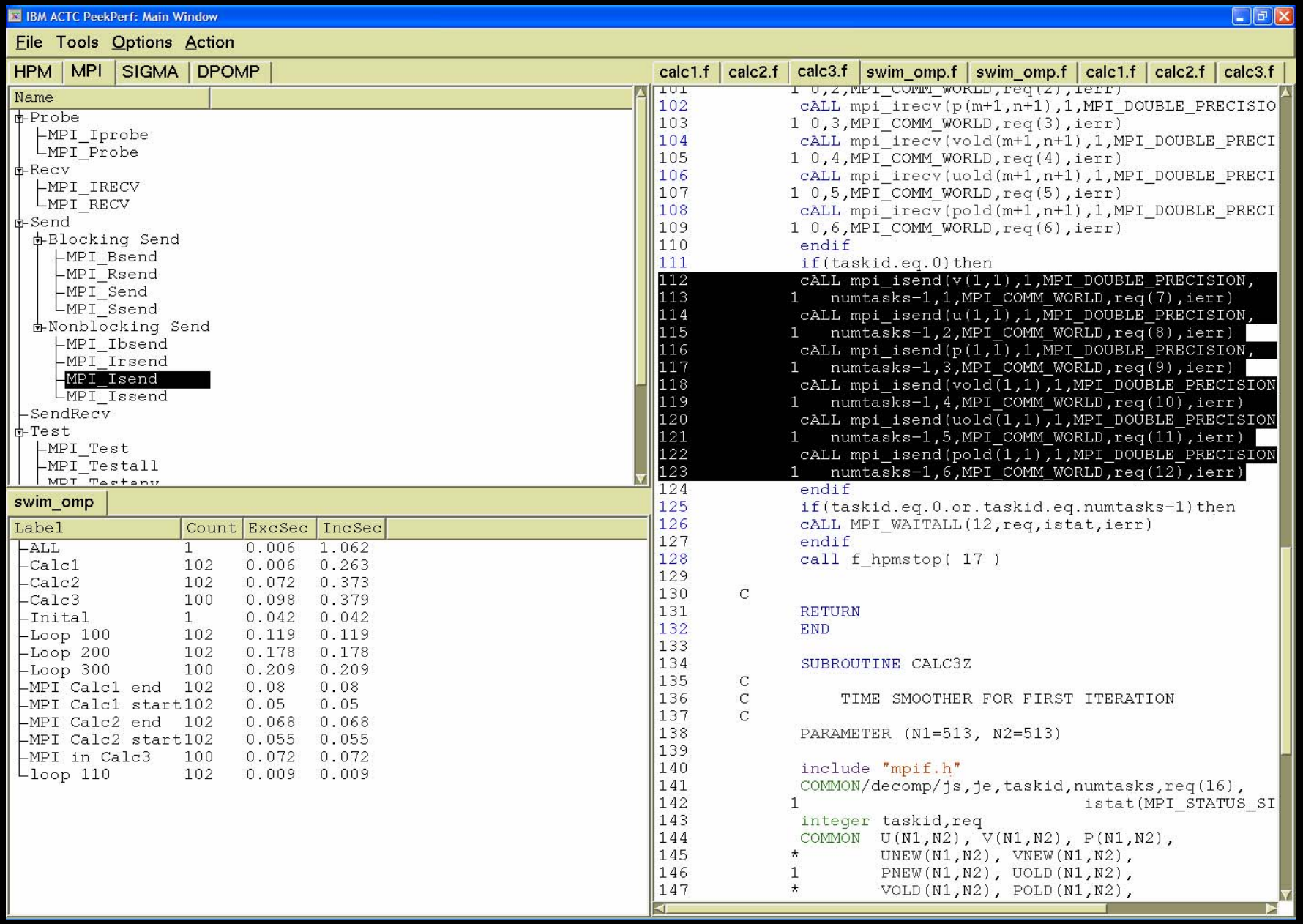
Symbolic Binary Instrumentation

Action Point Binary Instrumentation

Visualization







IBM HPC Toolkit Availability

- **IBM pSeries Servers**
  - Linux on Power
  - AIX on Power
- **All IBM Blue Gene systems**
  - Customers need to acquire additional licensing
  - Included in sitewide licenses for IBM Power systems
- **Work in Progress**
  - IBM Cell Server
  - Linux/Intel, Linux/AMD

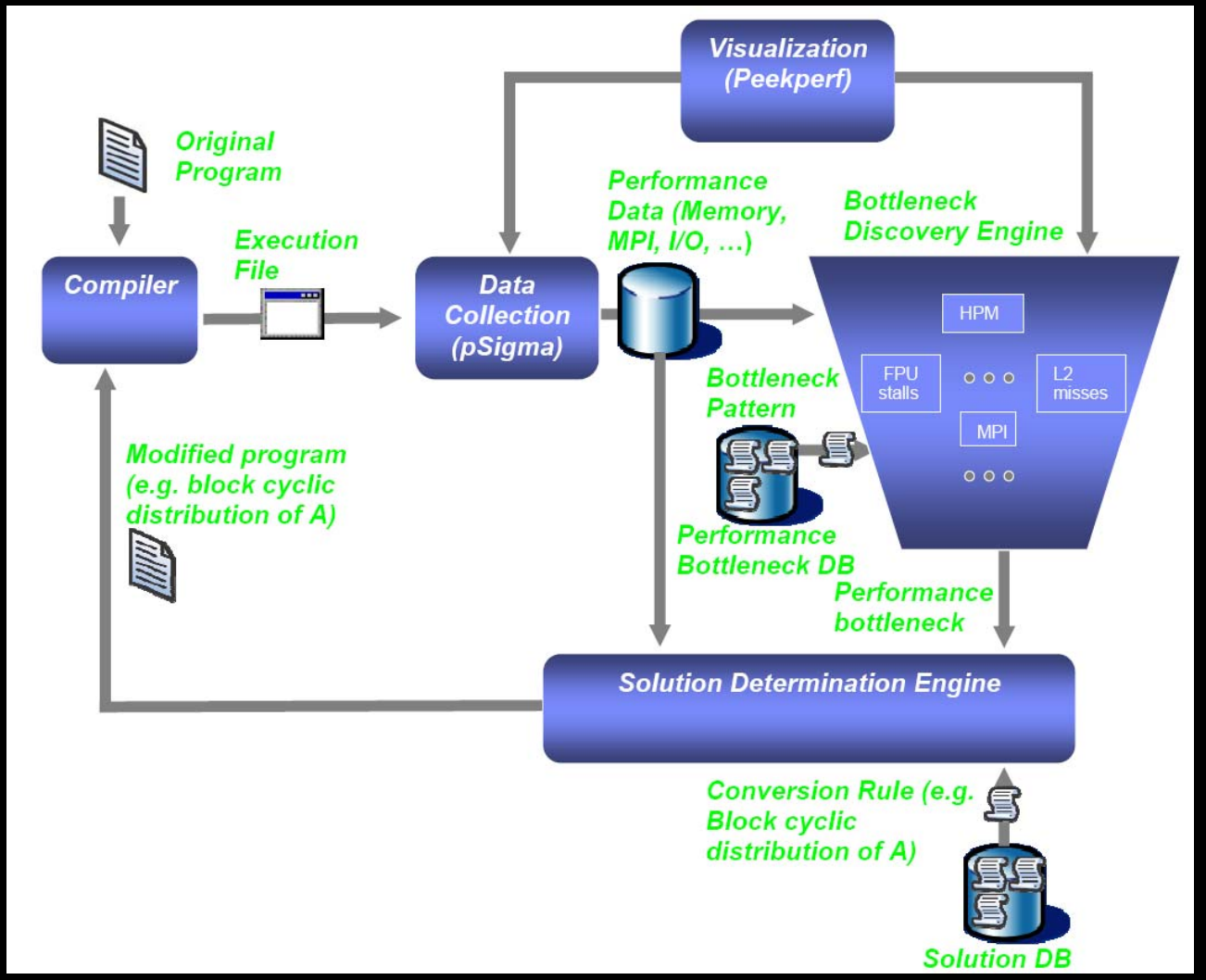
Sanity Check on System Evolution

- **Device Scaling imposing fundamental constraints on system**
  - Power dissipation and energy consumption
  - Physical size / packaging
- **Pressure to re-think system architecture**
  - Blue Gene: low power devices, embedded (small)
  - Cell: Attached (embedded) co-processing engine
- **Systems become inherently more complex**
  - Connectivity / hierarchical topology (torus, intra-cell)
  - Memory constraints (less per processor)
  - Additional technology “boosts” (hyper-threading, SMT)
- **This poses new challenge to application programming**
  - New programming paradigm? (not on horizon - legacy codes, ISV apps, etc.)
- **Conclusion: New software tools essential to mitigate evolving system complexity**

Automated Performance Tuning - HPCS

- **Performance Data Collection**
- **Bottleneck Discovery**
- **Solution Determination**
- **Performance Visualization**

High Level Design for HPCS Toolkit



Roadmap for DARPA (PERCS) Phase III

- **2007 Bottleneck Discovery Engine**
  - prototype software to demonstrate instrumentation and bottleneck determination capability
- **2008 Solution Determination Engine I**
  - prototype software to demonstrate solution determination for CPU and memory performance bottlenecks
- **2009 Solution Determination Engine II**
  - prototype software to demonstrate solution determination for MPI, and OpenMP thread bottlenecks
- **2010 Beta Release of HPCS Toolkit**
  - Full implementation of bottleneck discovery and solution determination, with user selectable source code solution implementation

IBM ACTC long-term goals

- **An automated performance tuning-assist framework**
  - Assist users to identify performance problems
  - Provide/Suggest possible solutions
- **A common application performance analysis environment across all HPC platforms**
  - Look at all aspects of performance (communication, memory, processor, I/O, etc) from within a single interface