PAPI, DynInst and Hardware Performance Analysis Tools

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The PAPI Interface

PAPI provides two standardized APIs to access the underlying performance counter hardware

- A low level interface designed for tool developers and expert users.
- The high level interface is for application engineers.

Overview of Talk

- Overview of PAPI
  - Features, Functionality and Usage
  - 2.3.4 Release Status
  - Changes coming in 3.0
- Dynamic Instrumentation
- Performance Analysis Tools
- Trends in the field

Purpose

The purpose of the PAPI project is to design, *standardize* and implement a portable and efficient API to access the hardware performance monitor counters found on most modern microprocessors.

Motivation

- To increase application performance and system throughput
- To characterize application and system workload on the CPU
- To stimulate performance tool development and research
- To stimulate research on more sophisticated feedback driven compilation techniques

Goals

- Provide a solid foundation for cross platform performance analysis *tools*.
- Loosely *standardize* interface among users, tool developers, vendors and academics.
- Provide implementations for the more popular HPC machines.
- Easy to use, well documented and freely available. (Truly Open Source)

The Fallacy of Good Scalability

- Engineers often report near linear scalability for large parallel application codes to hundreds of processors.
  - Closer inspection reveals poor per processor performance for their problem class.
  - How does one judge performance?
    - Do we have *good* algorithm? (maybe)
    - Do we have a *good* compiler? (?)
    - We need real performance data from the processor!

Peak Performance

- How fast is fast?
  - Single CPU performance in the scientific marketplace often results from good **data locality**, predictable branch behavior, and *instruction pipelines filled with independent instructions*. (Out-of-order scheduling and execution helps the latter 2)
  - Determining the “reuse potential” for a numerically intensive problem often dictates peak performance.
  - Certain ratios of metrics can help diagnose this problem. FP stalls vs. Mem stalls, loads vs. stores, misses vs. references, etc…

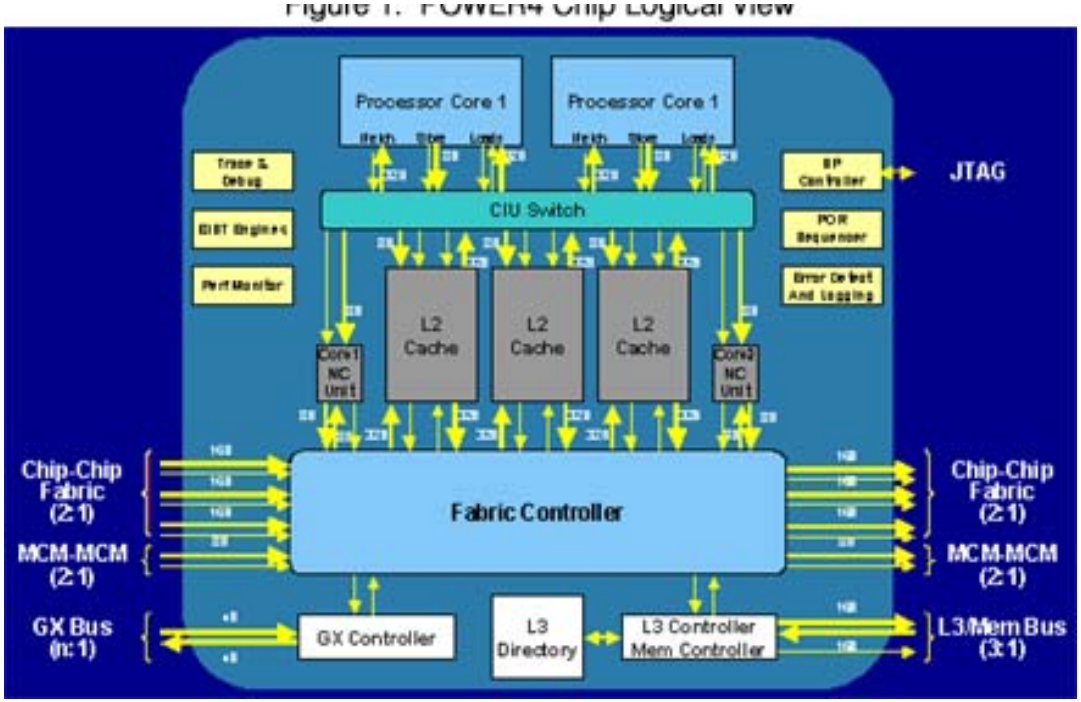
HPC Performance Analysis

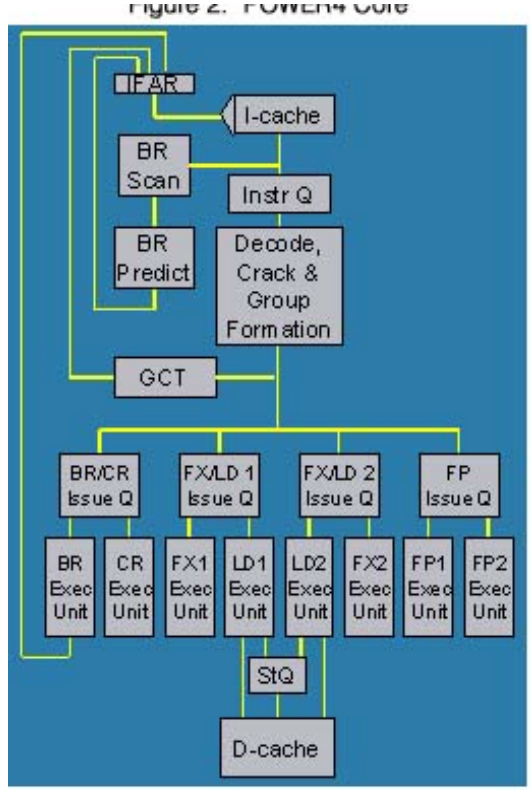
- Portability of an application is of the utmost concern to most HPC environments.
- No common performance tools except **`prof/gprof`**.
- *Most* commercial tools are based on time.
- HPC have memory and floating point intensive workloads which require detailed analysis.
- Research tools are the most common “solution” among the labs.

Overview of Hardware Counters

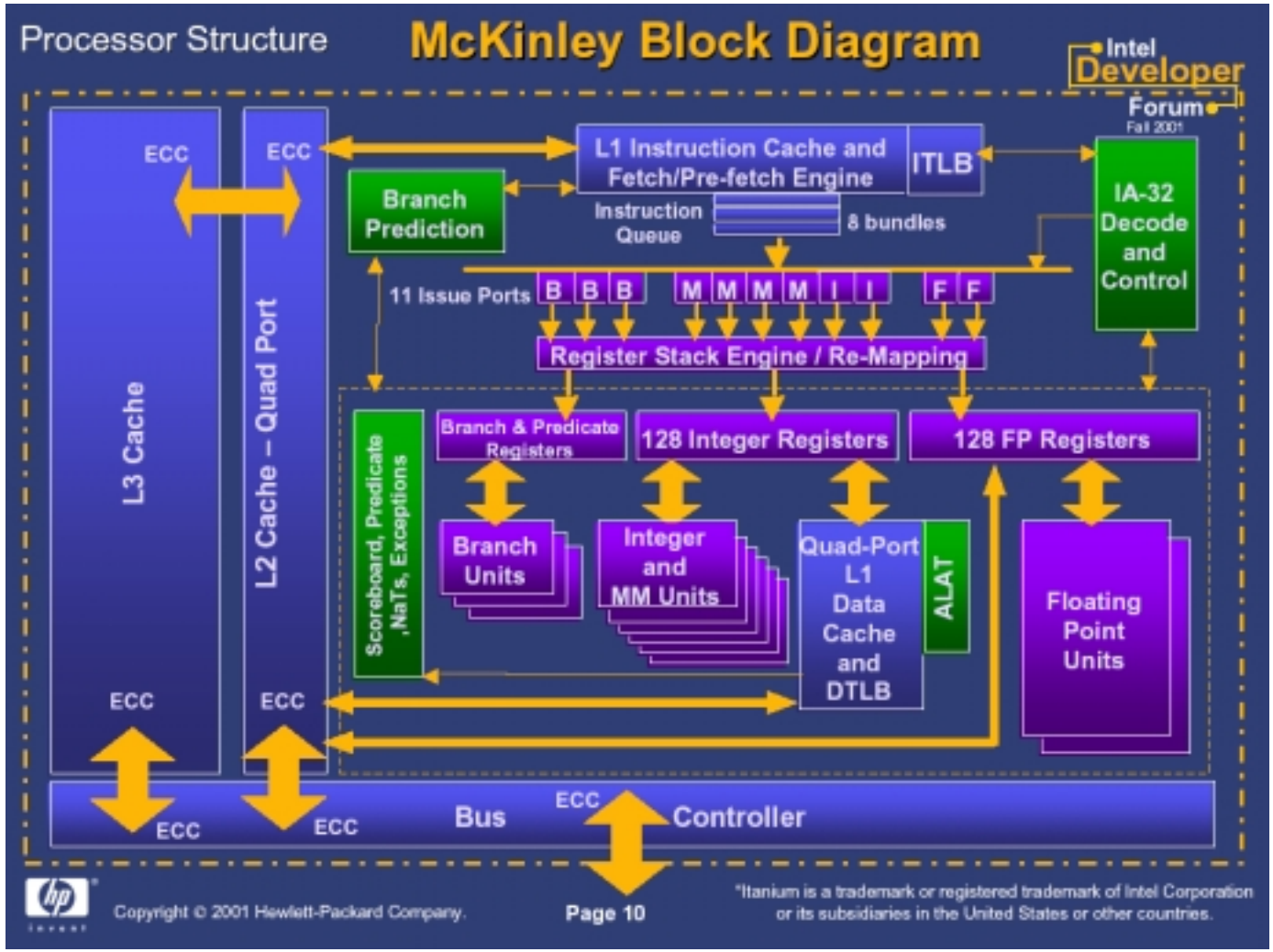
- Small number of registers dedicated for performance monitoring functions.
  1. AMD Athlon, 4 counters
  2. Pentium <= III, 2 counters
  3. Pentium IV, 18 counters
  4. IA64, 4 counters
  5. Alpha 21x64, 2 counters
  - Power 3, 8 counters
  - Power 4, 8 counters
  - UltraSparc II, 2 counters
  - MIPS R14K, 2 counters

Power 4 Module and Block Diagram

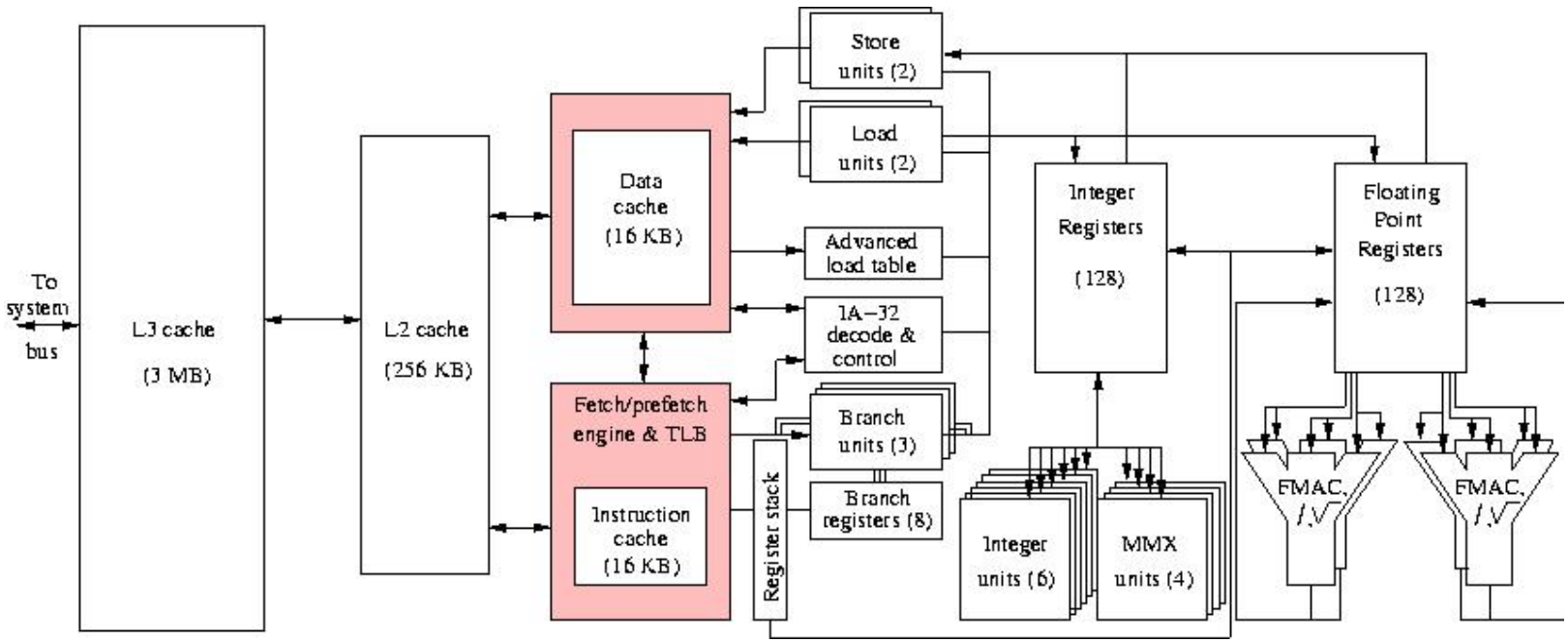




Itanium 2 Block Diagram

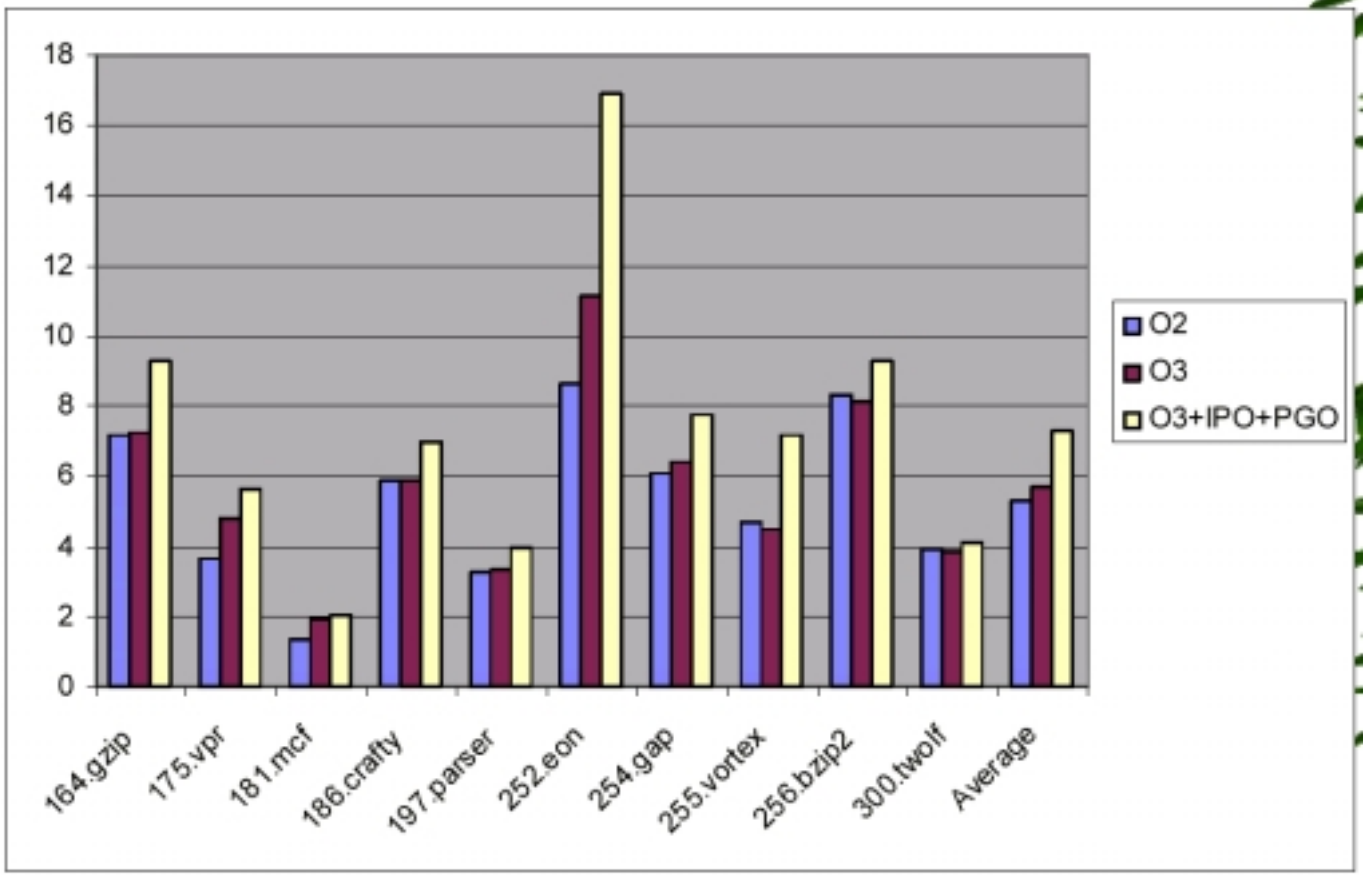


Itanium 2 Block Diagram

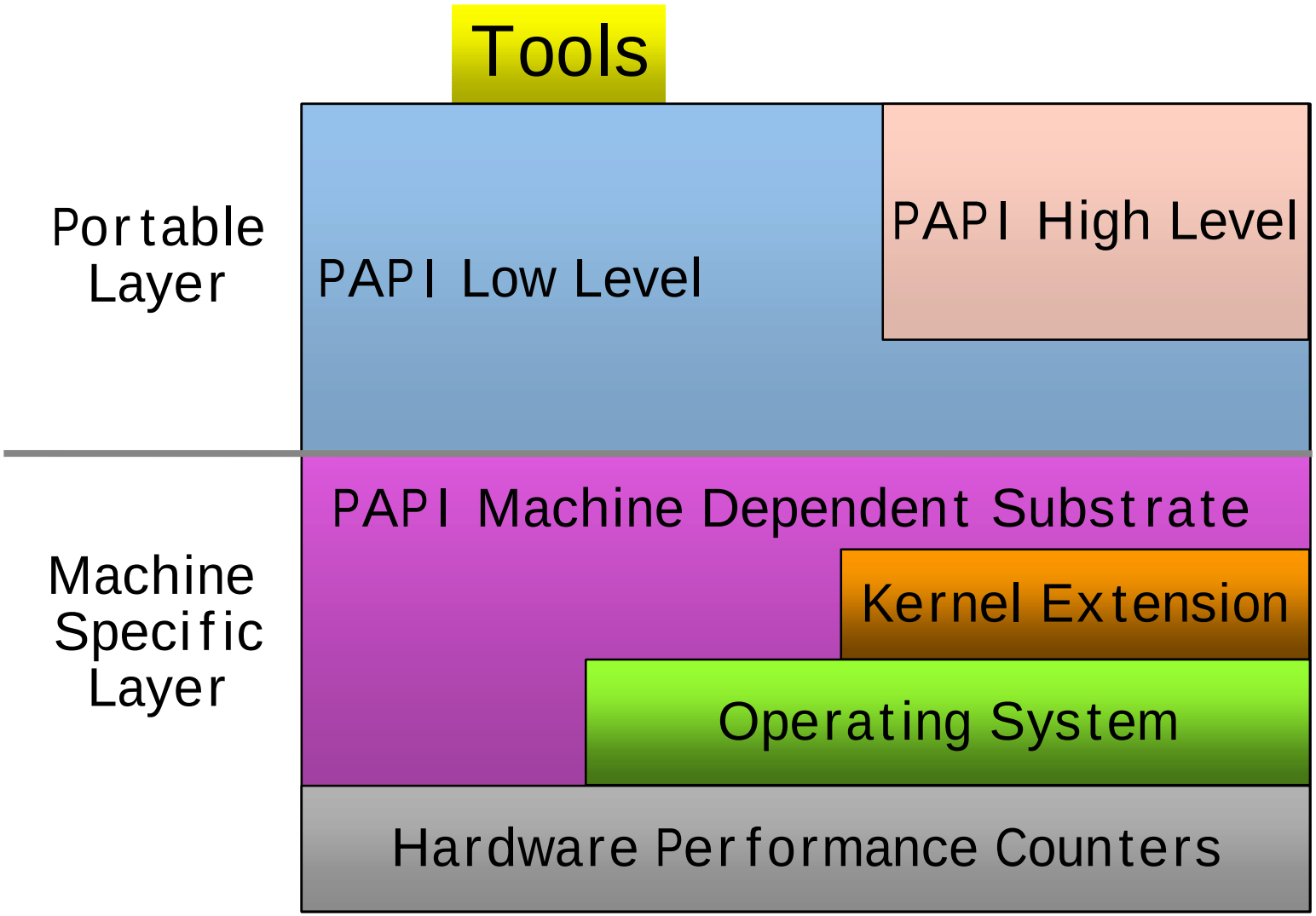


Importance of Optimization

Example: Speed up from Static Compiler Optimization on Itanium-I in 2002 (SpecInt)



PAPI Implementation



Preset Events

- Proposed standard set of event names deemed most relevant for application performance tuning
- No standardization of the actual definition
- Mapped to native events on a given platform

Preset Events 2

- PAPI supports approximately 100 preset events.
  - Preset events are mappings from symbolic names to machine specific definitions for a particular hardware event.
    - Example: **PAPI_TOT_CYC**
  - PAPI also supports presets that may be derived from the underlying hardware metrics
    - Example: **PAPI_L1_DCM**

Sample Preset Listing

```
Test case 8: Available events and hardware information.
-------------------------------------------------------------------------
Vendor string and code   : GenuineIntel (-1)
Model string and code    : Celeron (Mendocino) (6)
CPU revision             : 10.000000
CPU Megahertz            : 366.504944
-------------------------------------------------------------------------
Name         Code         Derived  Description (Note)
PAPI_L1_DCM  0x80000000   No       Level 1 data cache misses
PAPI_L1_ICM  0x80000001   No       Level 1 instruction cache misses
PAPI_L2_DCM  0x80000002   No       Level 2 data cache misses
PAPI_L2_ICM  0x80000003   No       Level 2 instruction cache misses
PAPI_L3_DCM  0x80000004   No       Level 3 data cache misses
PAPI_L3_ICM  0x80000005   No       Level 3 instruction cache misses
PAPI_L1_TCM  0x80000006   Yes      Level 1 cache misses
PAPI_L2_TCM  0x80000007   No       Level 2 cache misses
PAPI_L3_TCM  0x80000008   No       Level 3 cache misses
PAPI_CA_SNP  0x80000009   No       Requests for a snoop
PAPI_CA_SHR  0x8000000a   No       Requests for shared cache line
PAPI_CA_CLN  0x8000000b   No       Requests for clean cache line
PAPI_CA_INV  0x8000000c   No       Requests for cache line inv.
```

Native Events

- PAPI supports native events:
  - An event countable by the CPU can be counted even if there is no matching preset PAPI event.
  - The developer uses the same API as when setting up a preset event, but a CPU-specific bit pattern is used instead of the PAPI event definition.

High-level Interface

- Meant for application programmers wanting coarse-grained measurements
- As easy to use as the calls present in IRIX.
- Requires no setup code
- Restrictions:
  - Only PAPI preset events may be used
  - Not thread safe (in PAPI 2.3.4)

High-level API Calls

- **PAPI_num_counters()**
- **PAPI_start_counters(int *cntrs, int alen)**
- **PAPI_stop_counters(long_long *vals, int alen)**
- **PAPI_accum_counters(long_long *vals, int alen)**
- **PAPI_read_counters(long_long *vals, int alen)**
- **PAPI_flops(float *rtime, float *ptime,**
  long_long *flpins, float *mflops)

Low-level Interface

- Increased efficiency and functionality over the high level PAPI interface
- **Approximately 60 functions**

  (http://icl.cs.utk.edu/projects/papi/files/html_man/papi.html#4)
- Thread-safe for all 1:1 thread libraries. (Native, OpenMP, Pthreads, etc...)
- Supports both presets and native events

Low-level Functionality

- API Calls for:
  - Counter multiplexing
  - Callbacks on user defined overflow value
  - SVR4 compatible profiling
  - Processor information
  - Address space information
  - Static and dynamic memory information
  - Accurate and low latency timing functions
  - Hardware event inquiry functions
  - Eventset management functions
  - Simple locking operations

PAPI and Multiplexing

- Multiplexing allows simultaneous use of more counters than are supported by the hardware.
  - This is accomplished through timesharing the counter hardware and extrapolating the results.
- Users can enable multiplexing with one API call and then use PAPI normally.

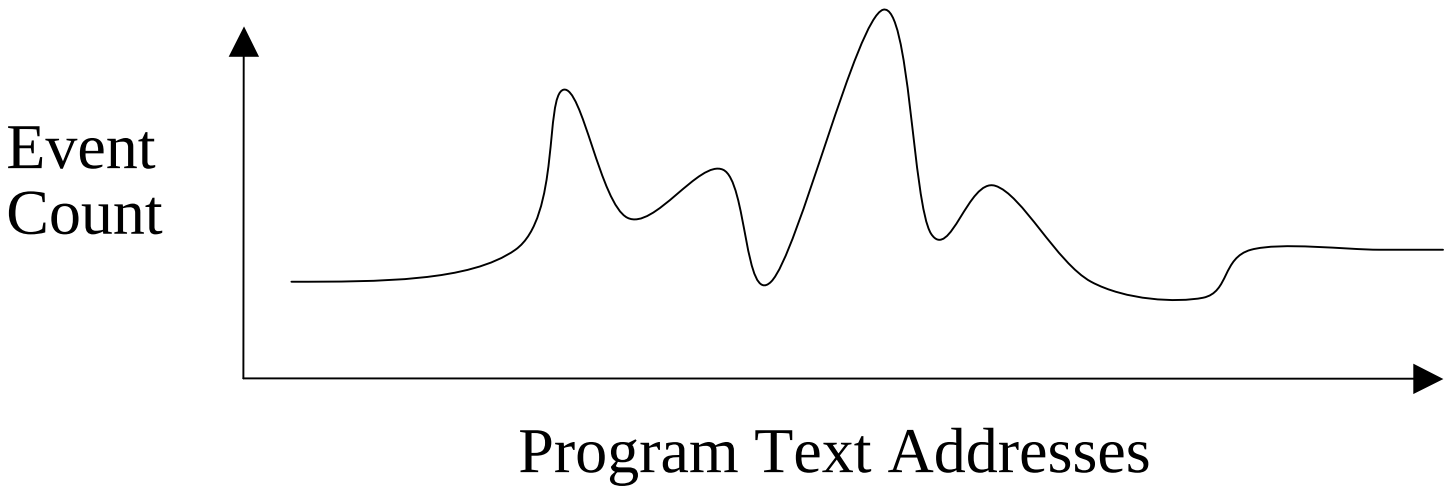
Interrupts on Counter Overflow

- PAPI provides the ability to call user-defined handlers when a specified event exceeds a specified threshold.
- For systems that do not support counter overflow at the hardware level, PAPI emulates this in software at the user level.
  - Code must run a reasonable length of time.

Hardware Profiling

- On overflow of hardware counter, dispatch a signal/interrupt.
- Get the address at which the code was interrupted.
- Store counts of interrupts for *each* address.
- Vendor/GNU **prof** and **gprof** (**-pg** and **–p** compiler options) use interval timers.

Results of Statistical Profiling



- The result: A probabilistic distribution of where the code spent its time and why.

For More Information

- http://icl.cs.utk.edu/projects/papi/
  - Software and documentation
  - Reference materials
  - Papers and presentations
  - Third-party tools
  - Mailing lists

PAPI 2.3.4 Release

- Supported Platforms
  - IBM 604, 604e, Power 3, 4
  - Intel x86, Pentium IV
  - Intel Itanium I, II
  - Sun UltraSparc I/II/III
  - SGI R10K/R12K/R14K
  - Compaq Alpha 21164/21264 with DADD/DCPI
  - Cray T3E
  - AMD Opteron
  - Windows/x86 (not PIV)
- Enhancements
  - Static/dynamic memory info
  - Multiplexing improvements
  - Lots of bug fixes

PAPI 3.0

- Using lessons learned from years earlier
  - Substrate code: 90% used only 10% of the time
- Complete internal redesign for:
  - Efficiency
  - Robustness
  - Feature Set
  - Elegance
  - Portability

Some PAPI 3.0 Features

- Multiway multiplexing
  - Use all available counter registers instead of one per time slice.
- Superb performance
  - Example: On Pentium 4, a PAPI_read() costs 230 cycles. (Register read costs 100 cycles)
- Full native and programmable event support
  - Thresholding
  - Instruction matching
  - Per event counting domains

PAPI 3.0 Features 2

- Third-party interface
  - Allows PAPI to control counters in other processes
- Internal timer/signal/thread abstractions
  - Support signal forwarding
- Additional internal layered API to support robust extensions

PAPI 3.0 Features 3

- Advanced profiling interface
  - Support profiling on multiple counters
  - Support hardware or operating system assisted profiling
- New sampling interface
  - P4, IA64 provide Event Address Registers of BTB misses, Cache misses, TLB misses, etc...
- Revised memory usage API
  - Process footprint

PAPI 3.0 Features 4

- System-wide and process wide counting implementation
- Expanded high level API
  - Thread safe
- New language bindings:
  - Java
  - Lisp
  - Matlab

PAPI 3.0 Release

- Initial release expected around SC 2003 (limited scope)
- Additional platforms will be added as they come available:
  - Cray X-1 (partially complete)
  - Nec SX-6
  - Blue Gene (BG/L)

DyninstAPI

- API for runtime code patching
  - new code can be added to a program while it executes
  - permits instrumentation and modification of programs
- Provides processor independent abstractions
  - same patching can be applied to multiple systems
- Includes metainstrumentation
  - tracks overhead on inserted code

IBM's DPCL vs. DynInst

- Parallel framework based on early DynInst
- Async/Sync operation
- Functions for getting data back to tool
- Integrated with POE
- Available on all HPC platforms (and Windows)
- Breakpoints
- Arbitrary ins. points
- Full Loop, CFG and Basic Block decoding

A Brief History of Dynamic Instrumentation

- Popularized by James Larus with EEL: An Executable Editor Library at U. Wisc.
  - http://www.cs.wisc.edu/~larus/eel.html
- Technology matured by Dr. Bart Miller and (now Dr.) Jeff Hollingsworth at U. Wisc.
  - DynInst Project at U. Maryland
    - http://www.dyninst.org/
  - IBM's DPCL: A Distributed DynInst
    - http://oss.software.ibm.com/dpcl/

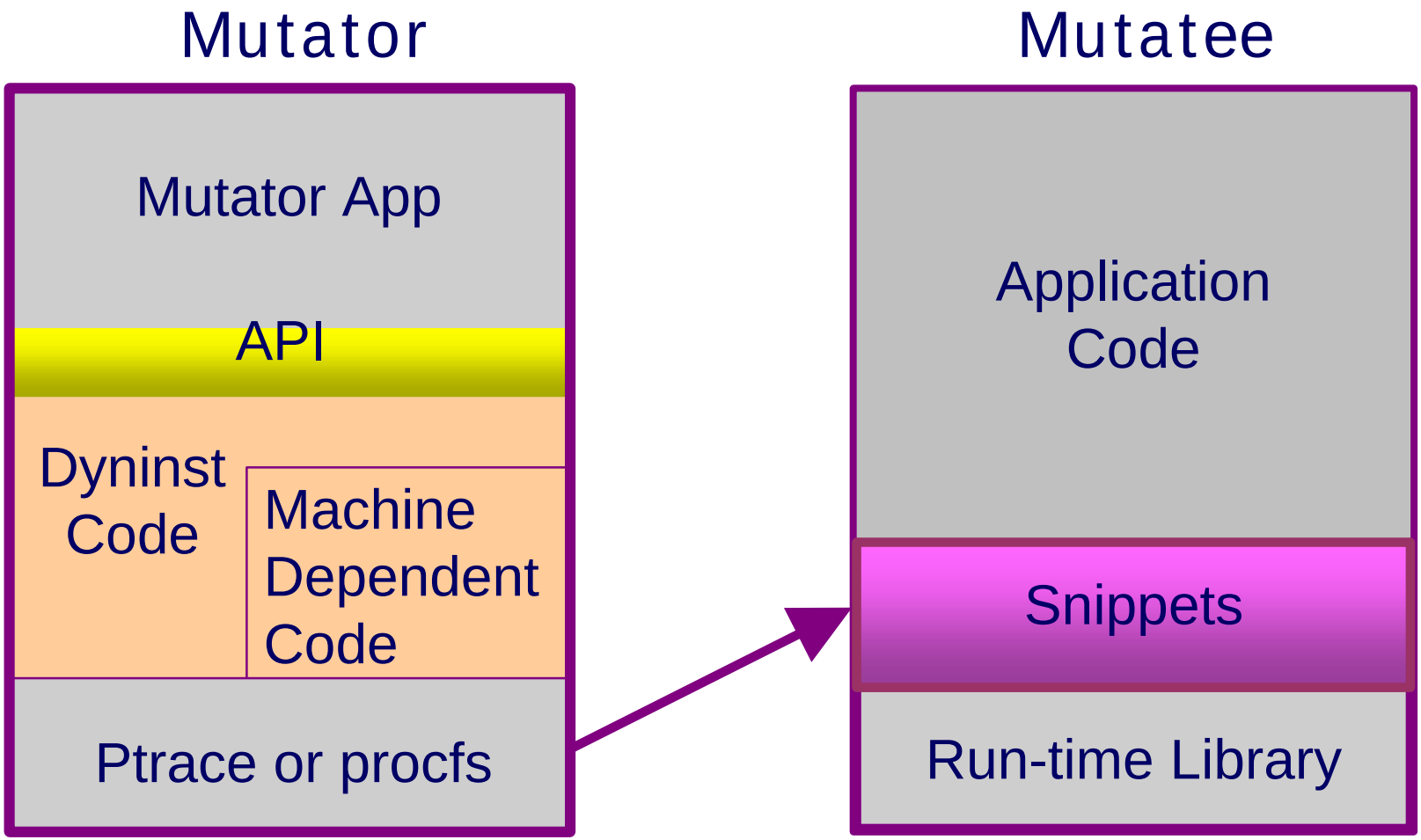
Why Runtime Code Patching?

- Performance measurement
  - Recording application behavior
- Correctness debugging
  - Fast conditional breakpoints
  - Data breakpoints
- Execution driven simulation
  - Architecture studies
- Testing
  - Code coverage testing
  - Forcing hard to execute paths to be taken

Advantages of Runtime Code Patching

- No forethought needed
  - No user inserted probes
  - No special compiling or linking
  - Start anytime during execution
- Only insert code when needed
  - No wasted checks for “disabled” code
  - Can add new code during execution

Structure of the Dyninst Library



API Library

- Provides:
  - Functions for control of mutatee
  - Runtime code generation
  - Information about mutatee
- A set of C++ classes
  - Bpatch_Thread
  - BPatch_image
  - BPatch_snippet
  - BPatch_variableExpr

Representing Code Snippets

- Platform Independent Representation
  - Same code can be inserted into apps on any system
- Simple Abstract Syntax Tree
  - Can refer to application state (variables & params)
  - Includes simple looping construct
  - Permits calls to application subroutines
- Type Checking
  - Ensures that snippets are type compatible
  - Based on structural equivalence
    - allows flexibility when adding new code

Type Support in Dyninst

- Access to local (stack) variables
- Complex types
  - non-integer scalars
  - structures
  - arrays
  - Fortran common blocks
- Correctness debugging
  - print contents of data structures

Fine-Grained Instrumentaton

- New classes added to dyninstAPI
  - BPatch_basicBlock
  - BPatch_sourceBlock
  - BPatch_flowGraph
- Arbitrary Instrumentation points
  - Conservative base trampoline
- Base trampoline deletion

Arbitrary Instrumentation Points

- Code Coverage needs basic block level instrumentation
  - dyninstAPI used to support function level instrumentation for sparc-solaris
  - added arbitrary instrumentation points for SPARC
- More state must be maintained in base trampolines
  - save/restore condition codes before/after arbitrary instrumentation points
  - Sparc arch supports user mode condition-code write/read for version v8plus and later

Memory Instrumentation

- Dynamic memory access instrumentation
  - collect low level memory accesses
  - with the flexibility of dynamic instrumentation
- Possible applications
  - offline performance analysis (Sigma etc.)
  - online optimization
  - tools to catch memory errors

Memory Instrumentation Features

- Finding memory access instructions
  - loads, stores, prefetches
- Builds on Arbitrary Instrumentation
- Decoded instruction information
  - type of instruction
  - constants and registers involved in computing
    - the effective address
    - the number of bytes moved
  - available in the mutator before execution
- Memory access snippets
  - effective address in process space
  - byte count
  - available in mutatee at execution time

Saving Binary Modifications

- Re-running with same modified code requires
  - Parse debug symbols
  - Two processes
  - DyninstAPI shared library
  - Time to re-insert instrumentation
- ***Not*** a checkpointing mechanism
  - Mutated binary begins at the top of main()
  - Data initialized as in original binary*

Dyninst Status

- Supported platforms
  - SPARC (Solaris)
  - x86 (Solaris, Linux, NT)
  - Alpha (Tru64 UNIX)
  - MIPS (IRIX)
  - Power/PowerPC (AIX)
- Software available on the web
  - **`http://www.dyninst.org`**
  - Includes TCL command tool
  - Over 250 sites have downloaded

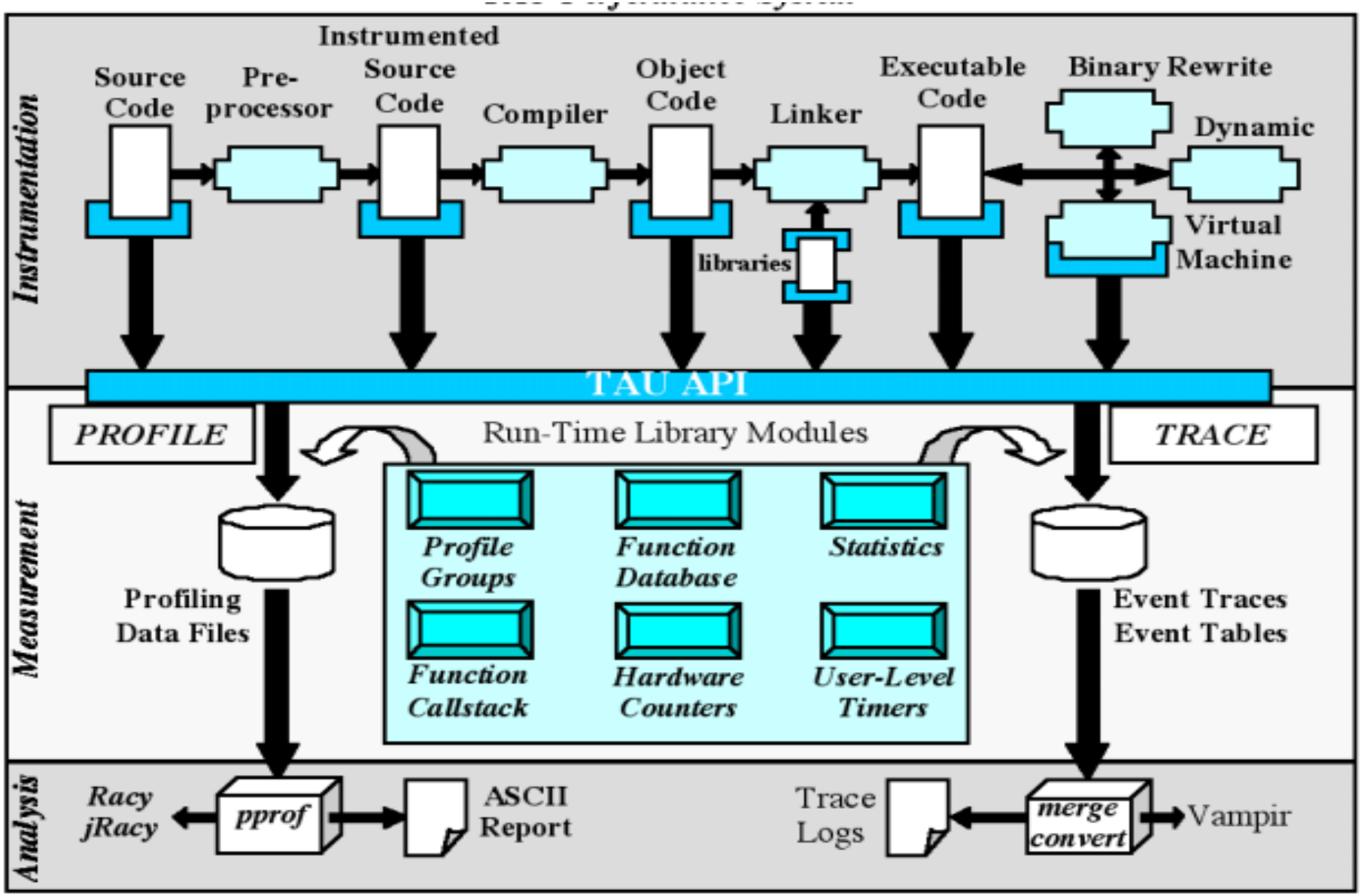
Paradyn from U. Wisconsin

- From Bart Miller Group
- Dynamic discovery of bottlenecks based on testing hypotheses
- Supports all forms of parallelism
- Different real-time visualization plugins
- Working with PAPI team to discover bottlenecks
- Just released version 4.0
- **http://www.paradyn.org**

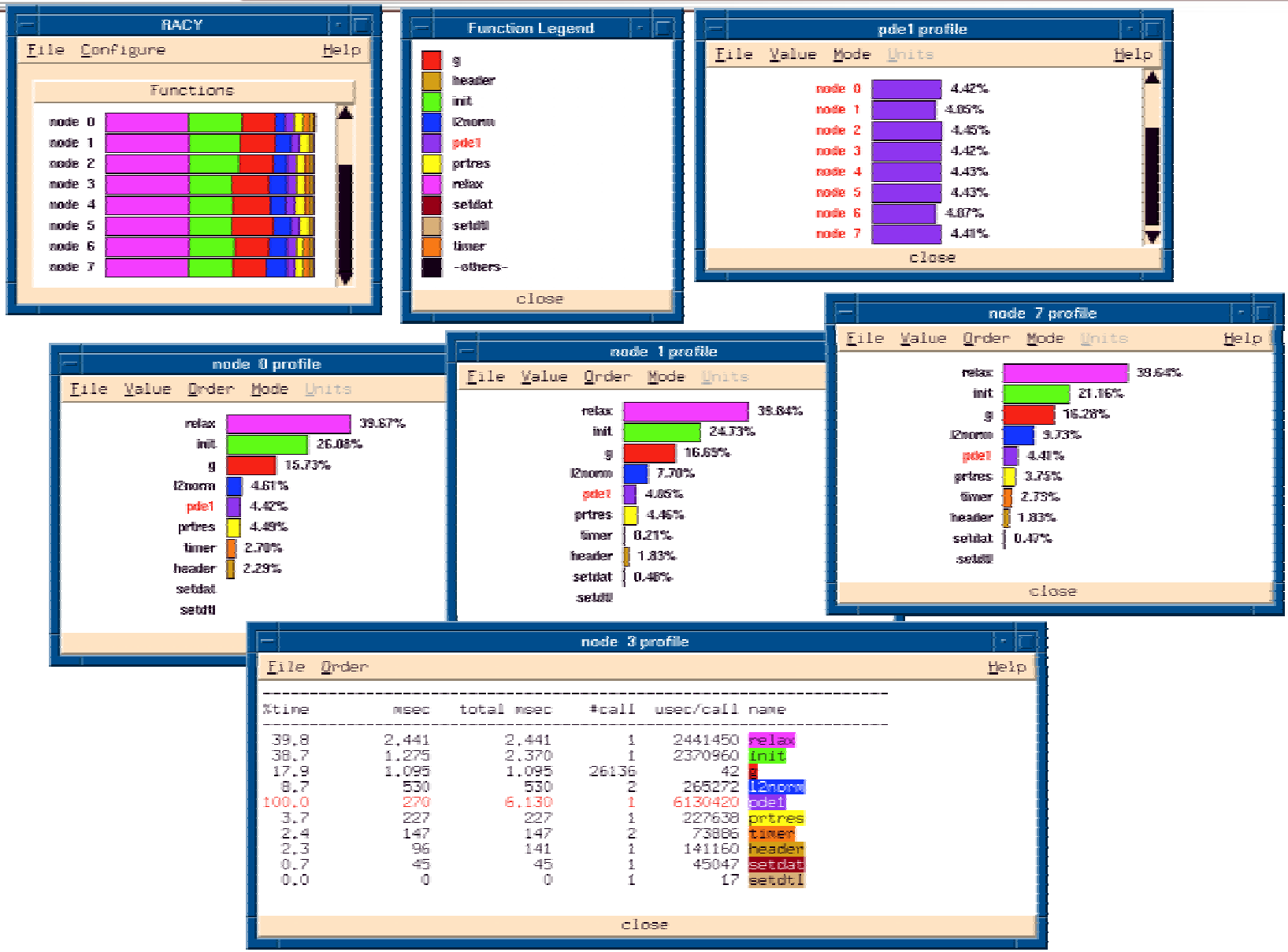
TAU from U. Oregon

- From Allen Malony's Group
- Source or binary based instrumentation
- Supports all forms of parallelism
- Integration with Vampir for trace visualization of MPI, OpenMP and both
- **`http://www.cs.uoregon.edu/research/paracomp/tau`**

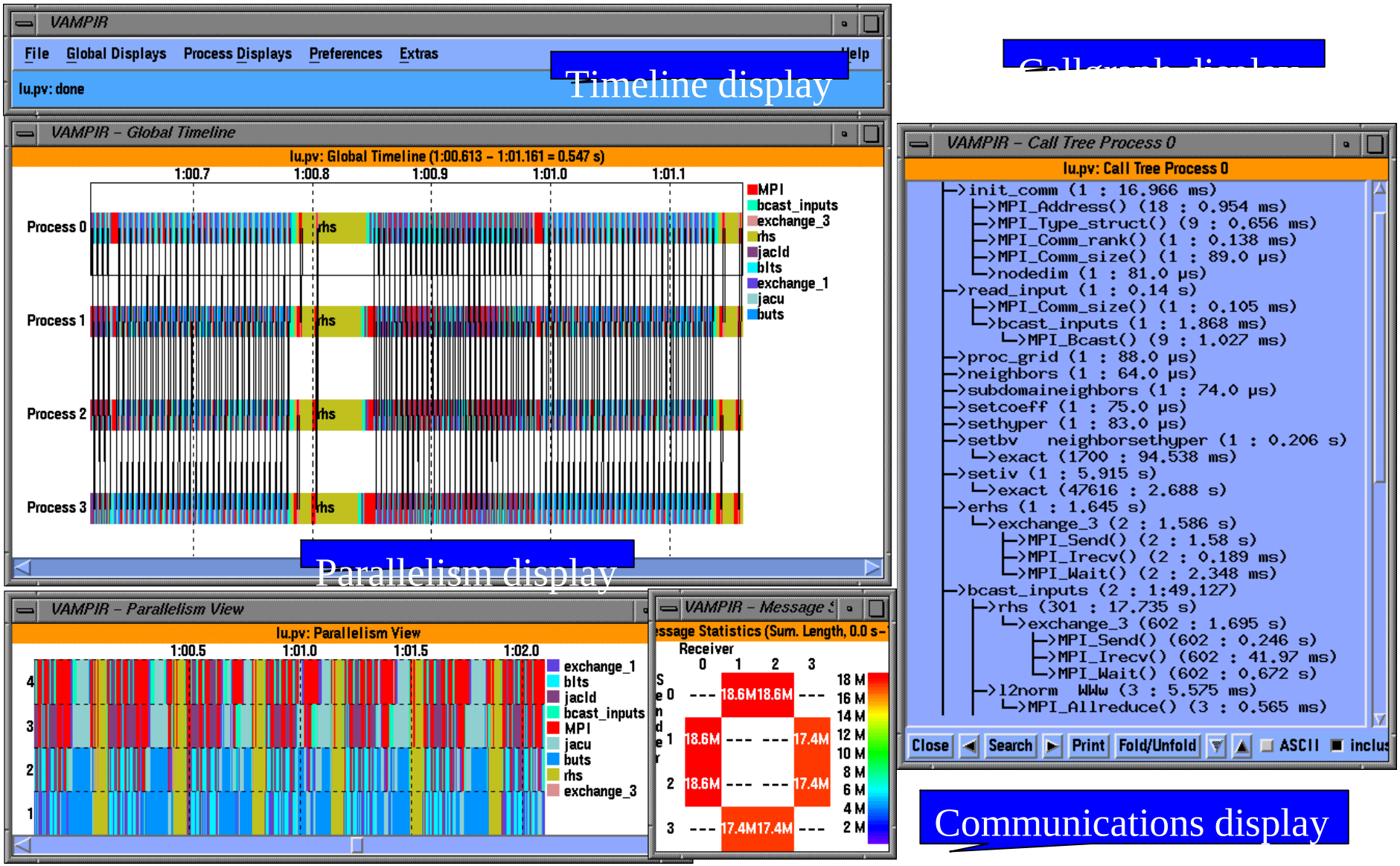
TAU System Architecture



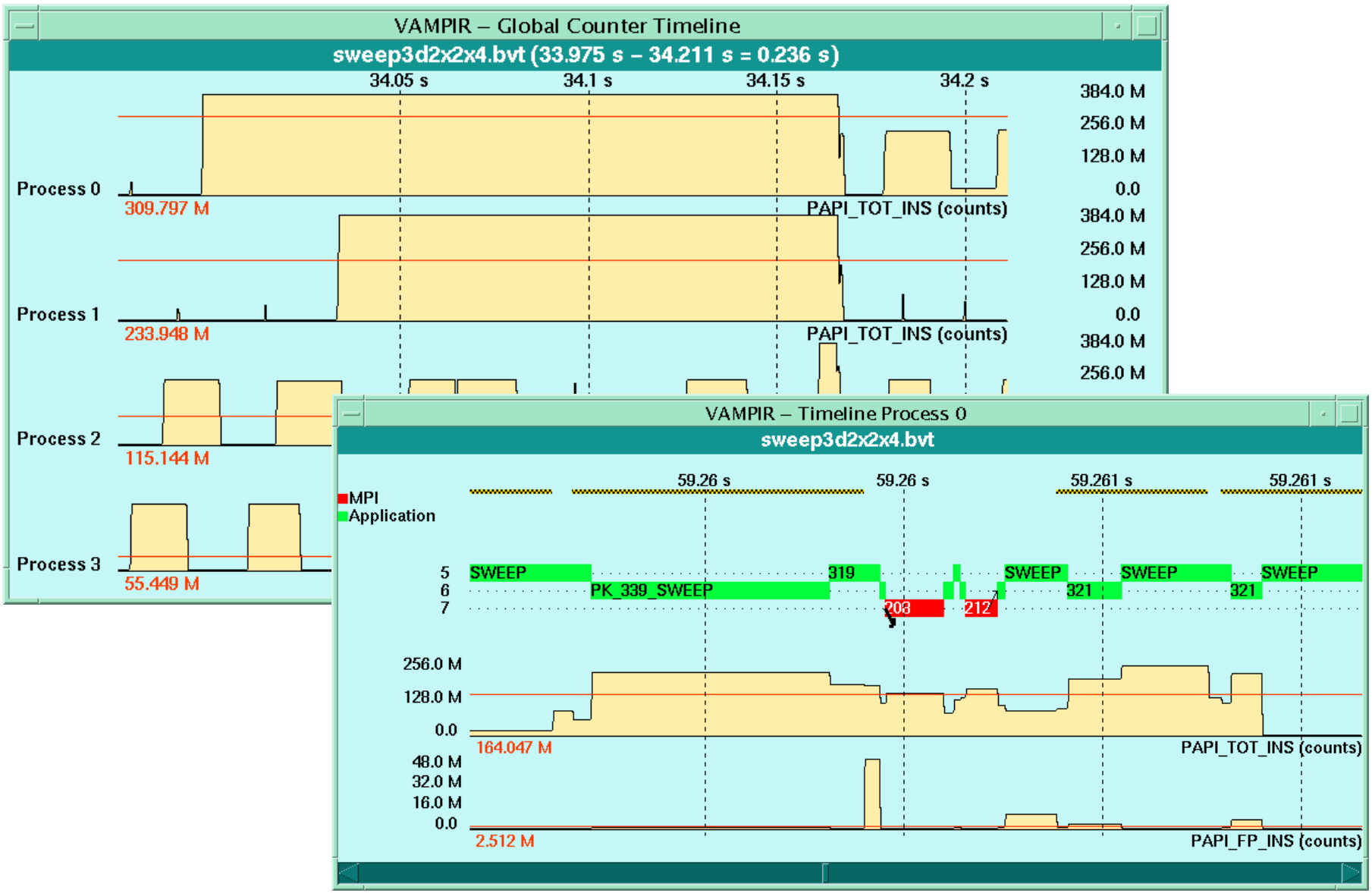
TAU/ParaProf Screenshot



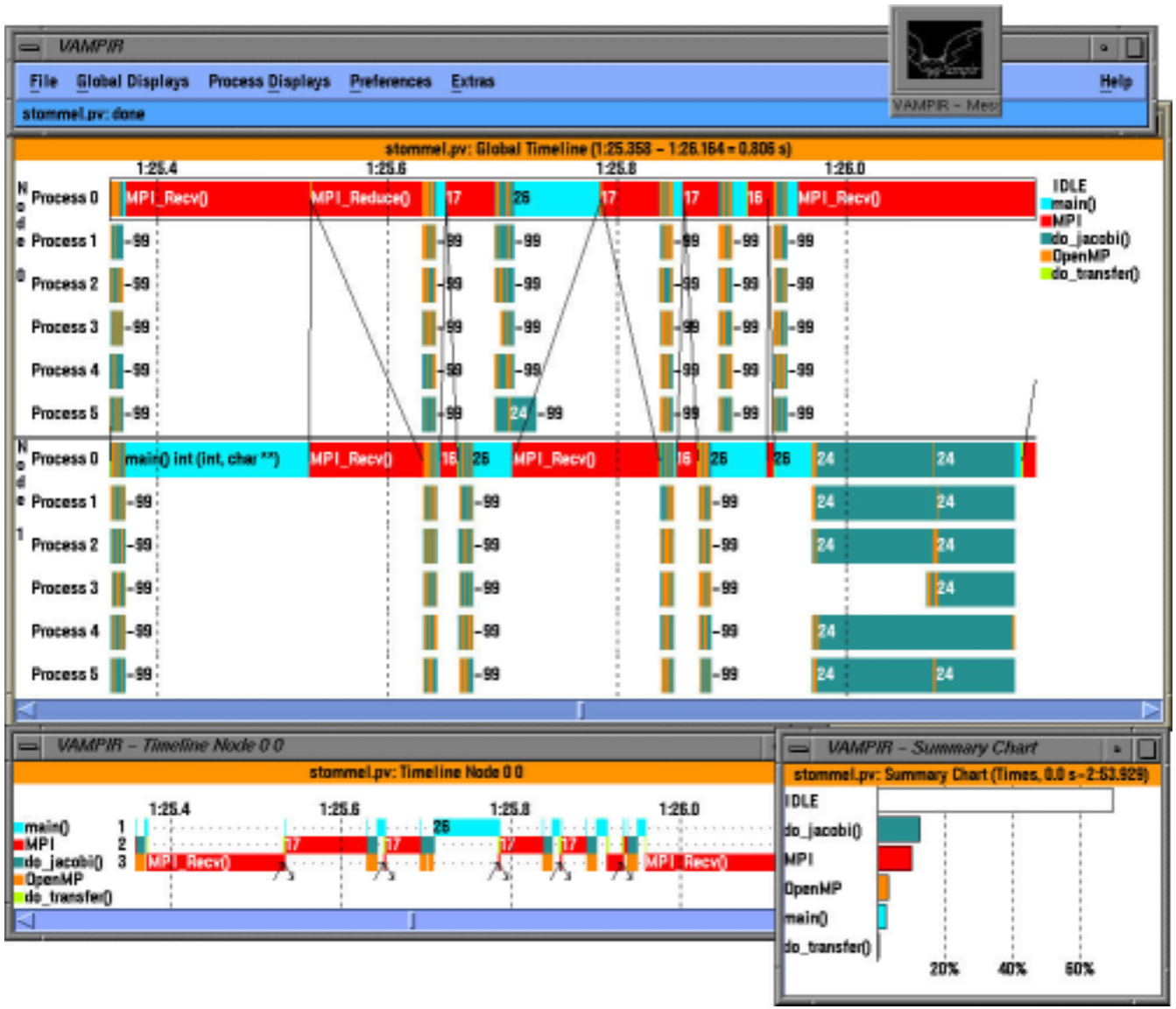
Vampir (NAS Parallel Benchmark – LU)



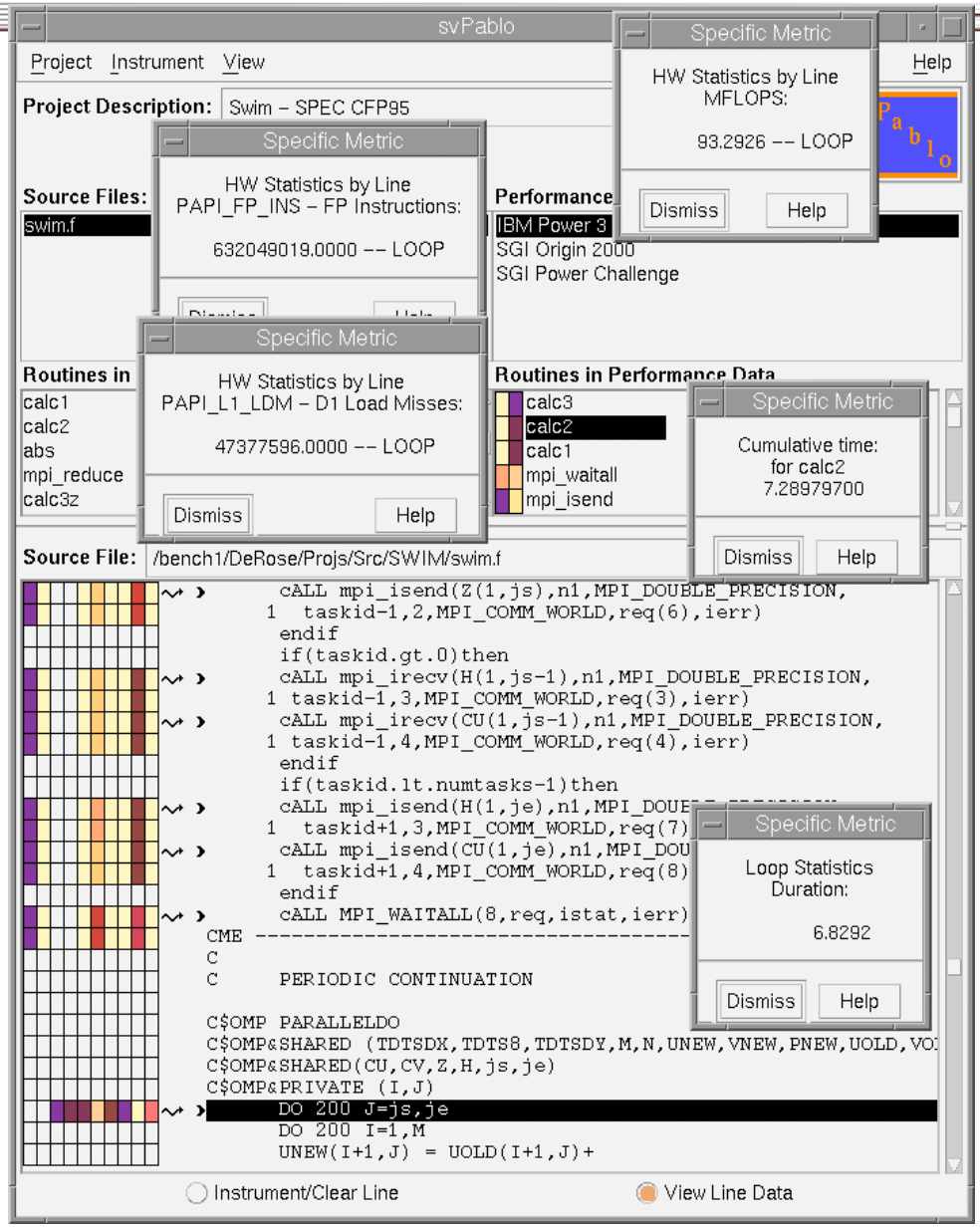
Vampir: PAPI Counter Traces



TAU OpenMP+MPI Vampir Visualization

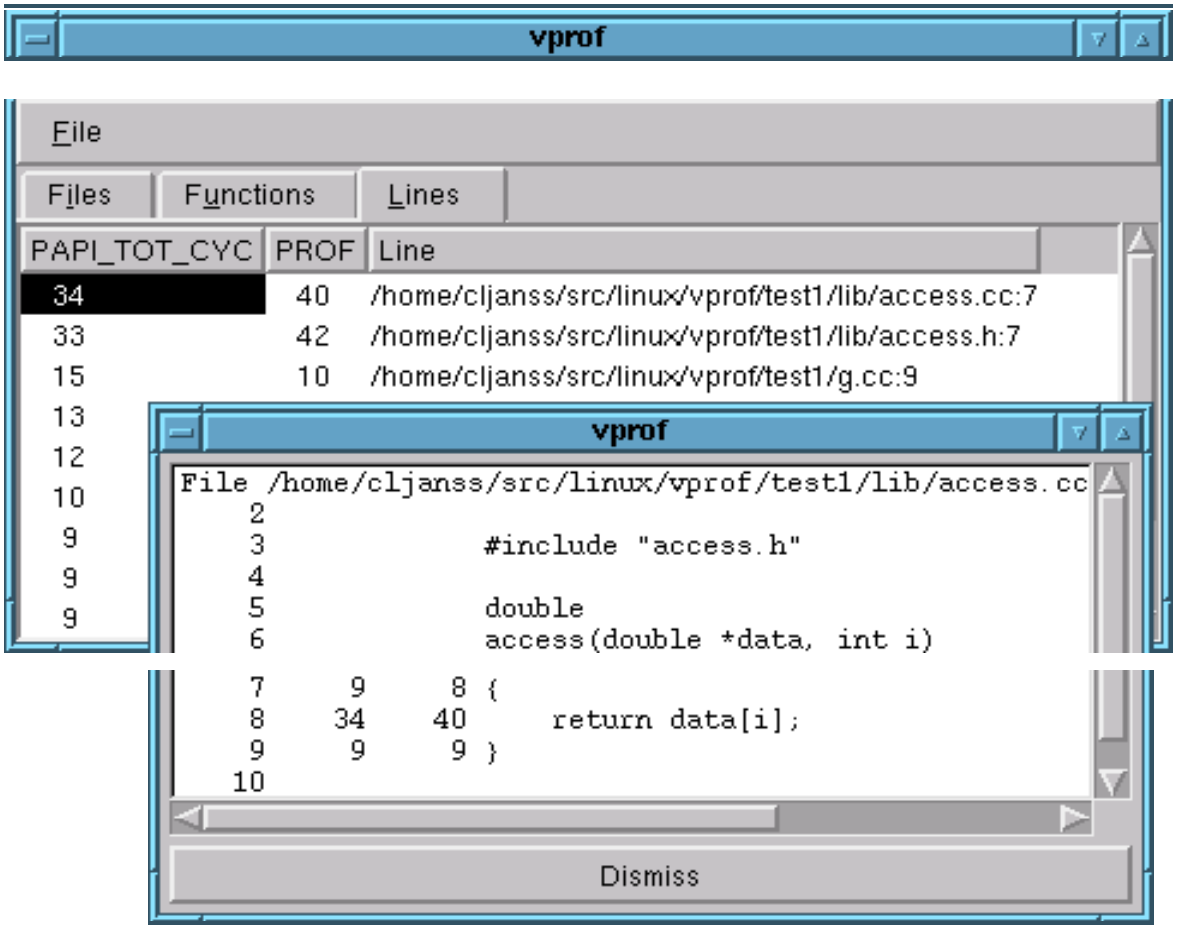


SvPablo from UIUC



- Source based instrumentation of loops and function calls
- Supports serial and MPI jobs
- Freely available
- Rough F90 parser

Vprof from Sandia National Laboratory



- Based on statistical sampling of the hardware counters
- Must instrument the source
- Ported to other architectures for generalized use
- Parallel codes with some modification
- Not actively supported

http://aros.ca.sandia.gov/~cljanss/perf/vprof

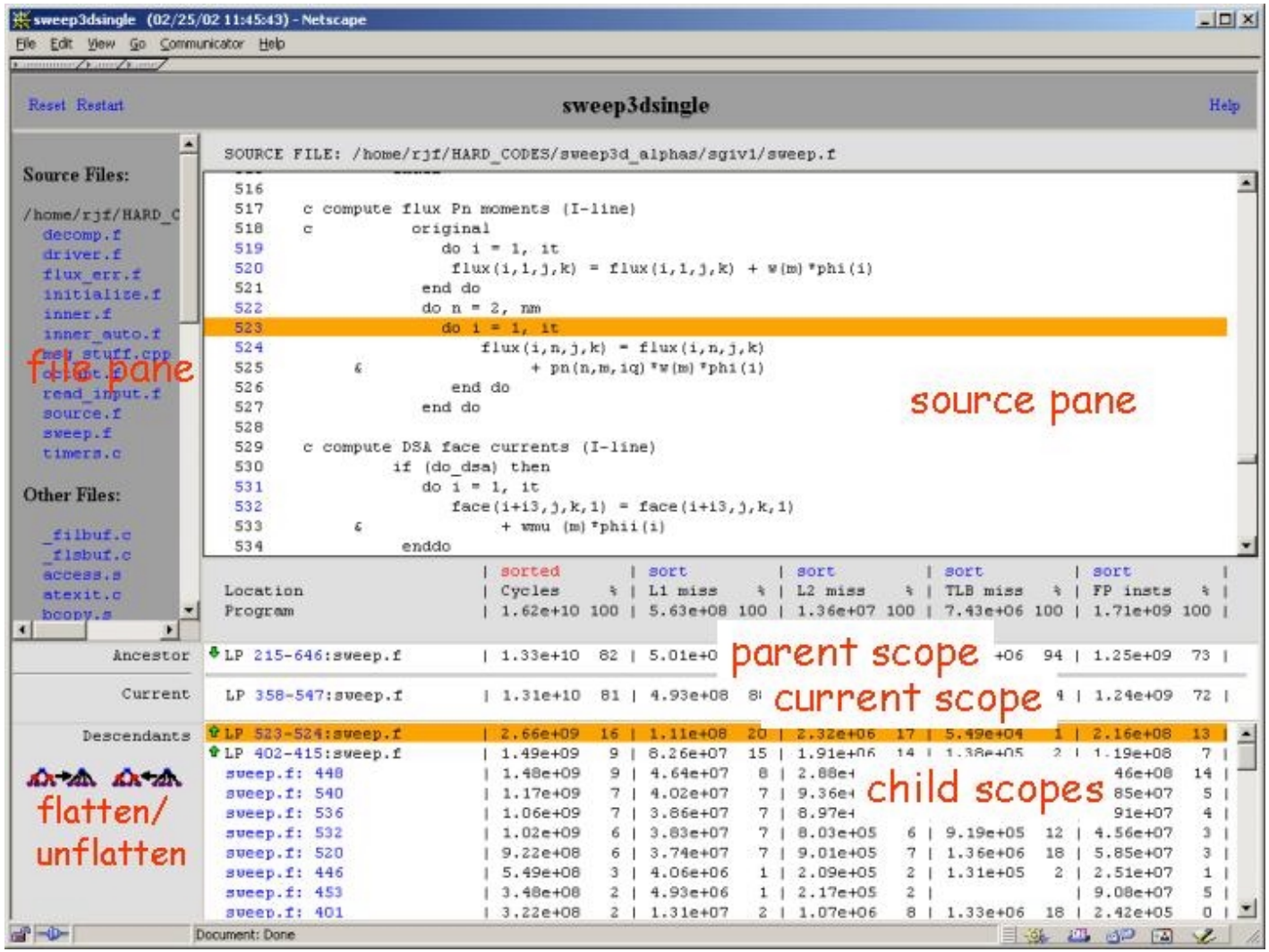
HPCToolkit from Rice University

- Tools for:
  - Collecting raw statistical profiles
  - Conversion of profiles into platform independent XML
  - Synthesizing browsable representations that correlate metrics with source code
- http://www.hipersoft.rice.edu/hpctoolkit

HPCToolkit Tools

- Collection: papirun/hvprof, equivalent to SGI's “ssrun”
- Loop/CFG recovery from binary: bloop
- Data formatting: papiprof
- Data display and exploration: hpcview
- Call stack profiles: csprof
- Data is aggregated into an XML database
- HPCView is a Java applet that generates dynamic HTML

HPCView Screenshot



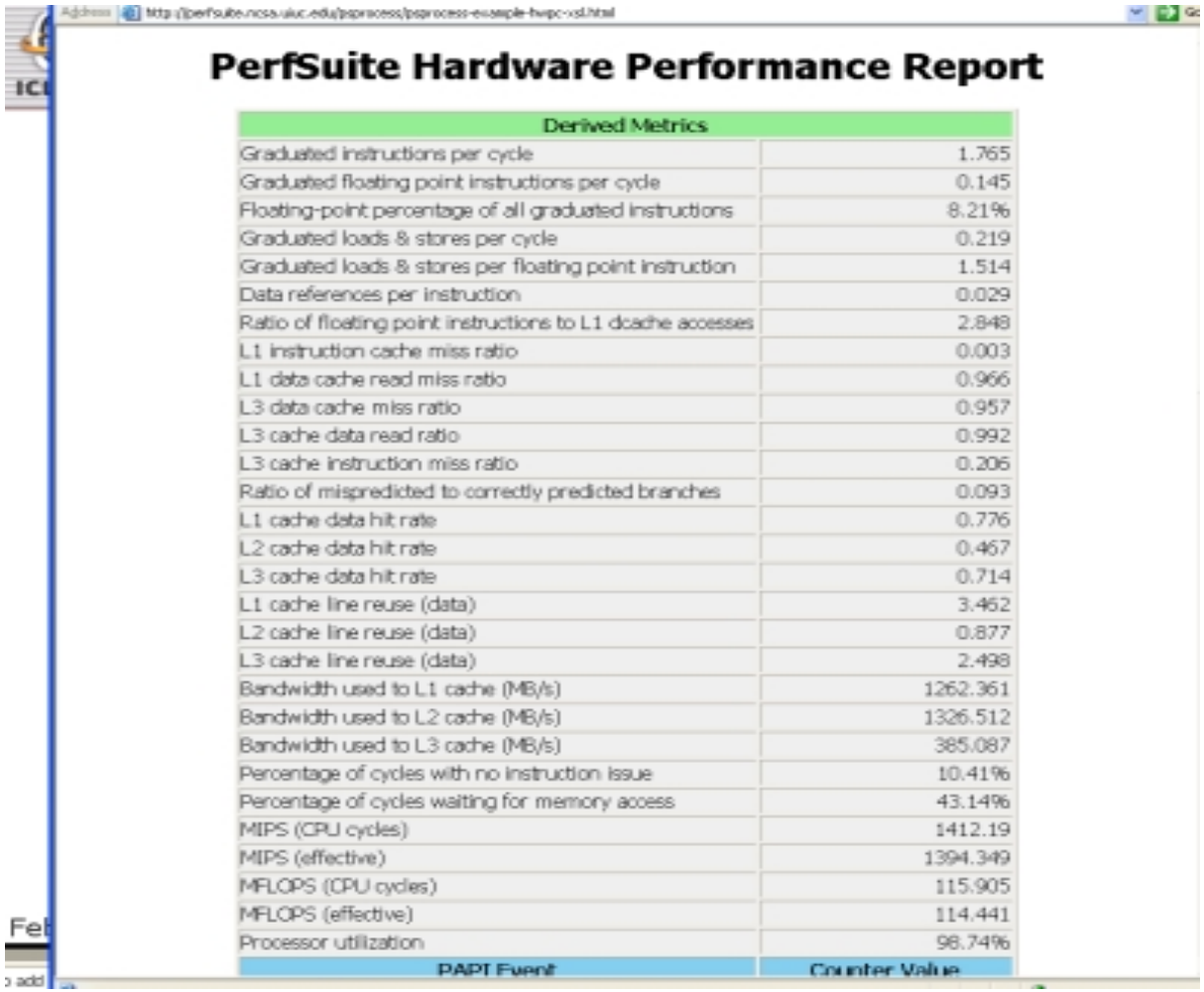
PerfSuite from NCSA

- Libraries and tools for machine information, memory information, aggregate counts, derived metrics and statistical profiles
- Targeted for x86 and IA64 systems
- http://perfsuite.ncsa.uiuc.edu

PerfSuite Tools

- psinv: Gather information on a processor and the PAPI events it supports
- psrun: Collection of aggregate/derived counts or statistical profiles of unmodified binaries
- psprocess: Formatting and output of psrun data into text or HTML

Psprocess Example Output



PerfSuite Hardware Performance Report

Derived Metrics	
Graduated instructions per cycle	1.765
Graduated floating point instructions per cycle	0.145
Floating-point percentage of all graduated instructions	8.21%
Graduated loads & stores per cycle	0.219
Graduated loads & stores per floating point instruction	1.514
Data references per instruction	0.029
Ratio of floating point instructions to L1 dcache accesses	2.848
L1 instruction cache miss ratio	0.003
L1 data cache read miss ratio	0.966
L3 data cache miss ratio	0.957
L3 cache data read ratio	0.992
L3 cache instruction miss ratio	0.206
Ratio of mispredicted to correctly predicted branches	0.093
L1 cache data hit rate	0.776
L2 cache data hit rate	0.467
L3 cache data hit rate	0.714
L1 cache line reuse (data)	3.462
L2 cache line reuse (data)	0.877
L3 cache line reuse (data)	2.498
Bandwidth used to L1 cache (MB/s)	1262.361
Bandwidth used to L2 cache (MB/s)	1326.512
Bandwidth used to L3 cache (MB/s)	385.087
Percentage of cycles with no instruction issue	10.41%
Percentage of cycles waiting for memory access	43.14%
MIPS (CPU cycles)	1412.19
MIPS (effective)	1394.349
MFLOPS (CPU cycles)	115.905
MFLOPS (effective)	114.441
Processor utilization	98.74%
PAPI Event	Counter Value

Psrun Statistical Profile Example Output

Function Summary

Samples	Self %	Total %	Function
1839543	35.01%	35.01%	inl3130
541829	10.31%	45.32%	ns5_core
389741	7.42%	52.74%	inl0100
355349	6.76%	59.51%	spread_q_bsplines
213172	4.06%	63.56%	gather_f_bsplines
200546	3.82%	67.38%	do_longrange
182691	3.48%	70.86%	make_bsplines
149924	2.85%	73.71%	ewald_LRcorrection
112883	2.15%	75.86%	inl3100
105317	2.00%	77.86%	solve_pme
92257	1.76%	79.62%	flincs

PerfSuite Libraries

- libperfsuite: Provides simple wrappers for machine information, process memory usage and high-precision timing
- libpshwpc: Provides simple wrappers that are used to collect hardware performance data

Libpshwpc Example

```
 program mxm
 include 'fperfsuite.h'

c Initialize libpshwpc

      call PSF_hwpc_init(ierr)

c Start performance counting using libpshwpc

      call PSF_hwpc_start(ierr)

c Stop hardware performance counting and write the
c results to a file named 'perf.XXXXX' (XXXXX will be
c replaced by the process ID of the program)

      call PSF_hwpc_stop('perf', ierr)

c Shutdown use of libpshwpc and the underlying libraries

      call PSF_hwpc_shutdown(ierr)
```

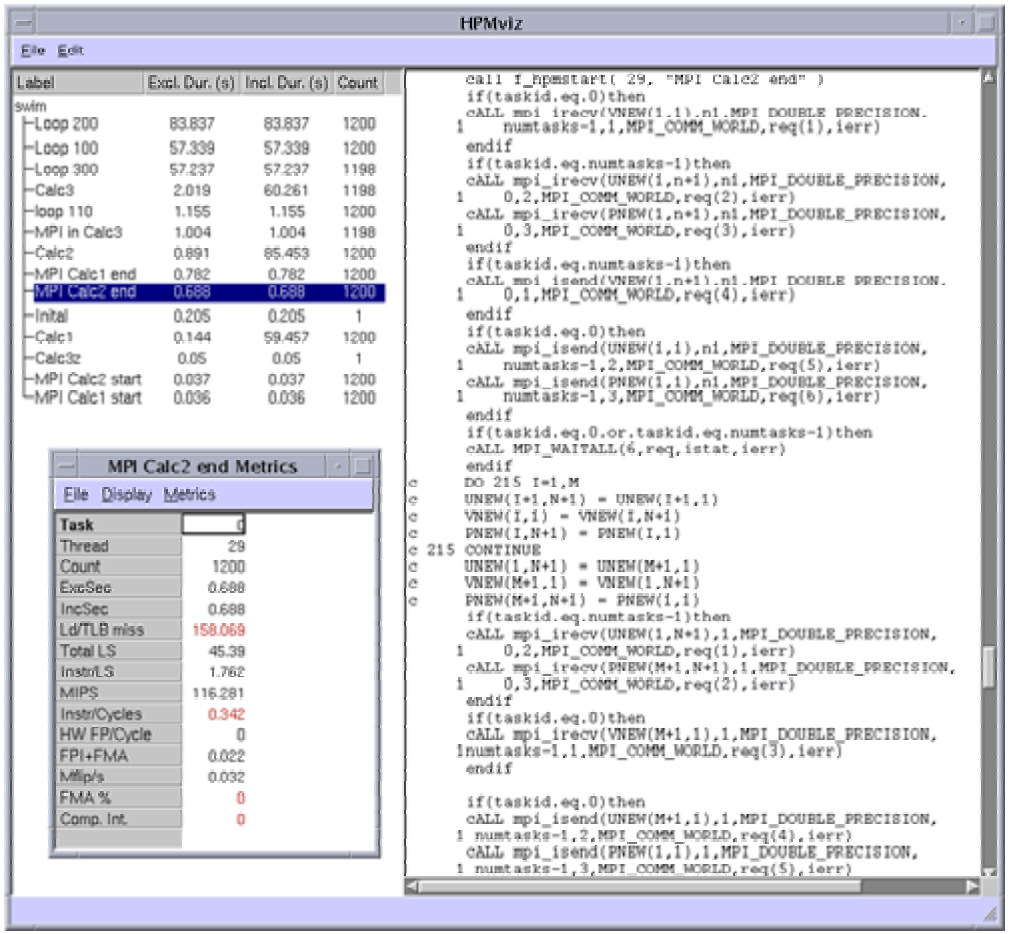
- Environment variables and XML input file dictate what gets measured

HPMToolkit from IBM ACTC

- Command line utility to gather aggregate counts.
  - PAPI version has been tested on IA32 & IA64
  - User can manually instrument code for more specific information
  - Reports derived metrics like SGI's perfex
- Libhpm for manual instrumentation
- Hpmviz is a GUI to view resulting data

http://www.ncsa.uiuc.edu/UserInfo/Resources/Software/Tools/HPMToolkit

hpmviz Screenshot



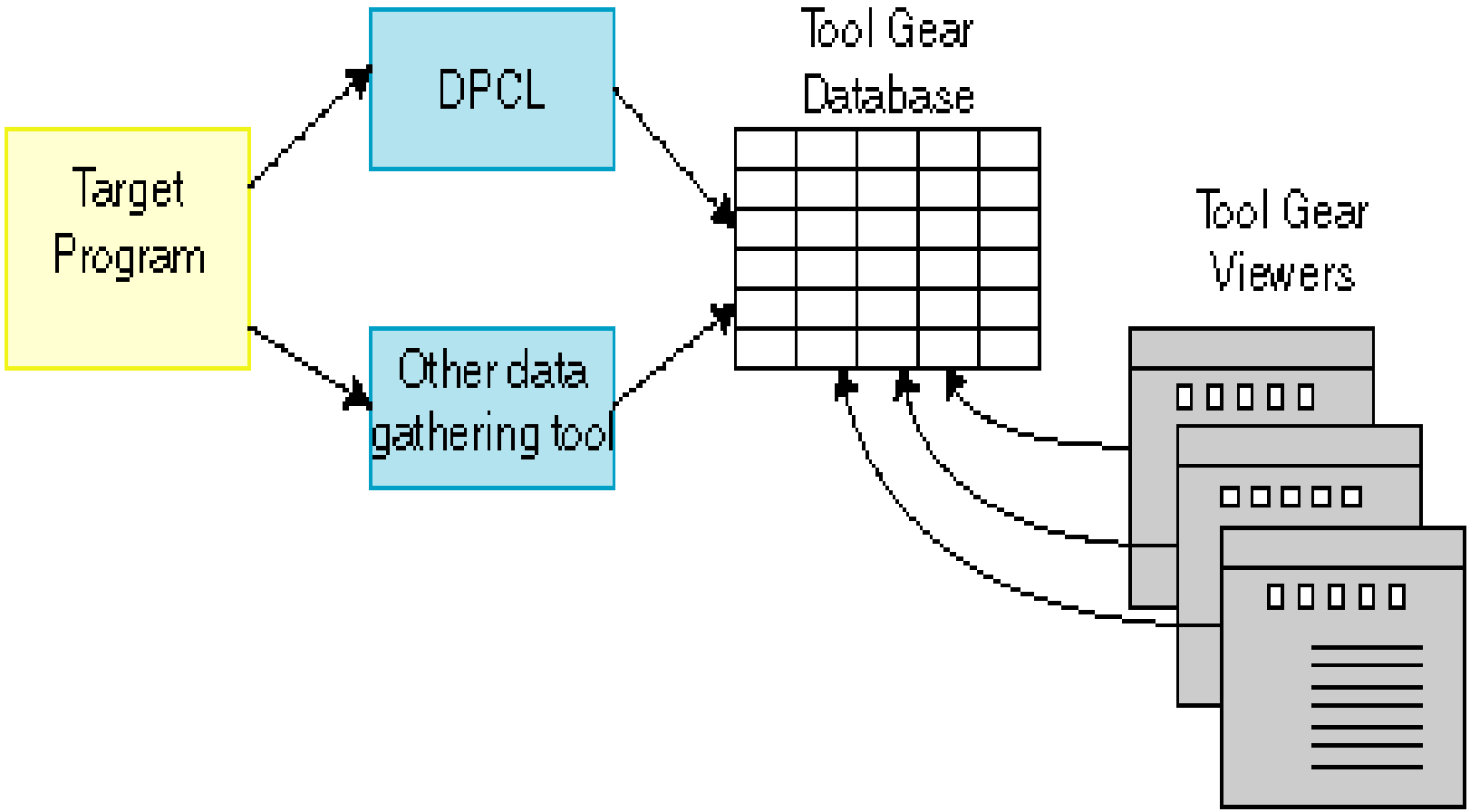
Libhpm Example

```
#include "libhpm.h"
hpmInit( tasked, "my program" );
hpmStart( 1, "outer call" );
do_work();
hpmStart( 2, "computing meaning of life" );
do_more_work();
hpmStop( 2 );
hpmStop( 1 );
hpmTerminate( taskID );
```

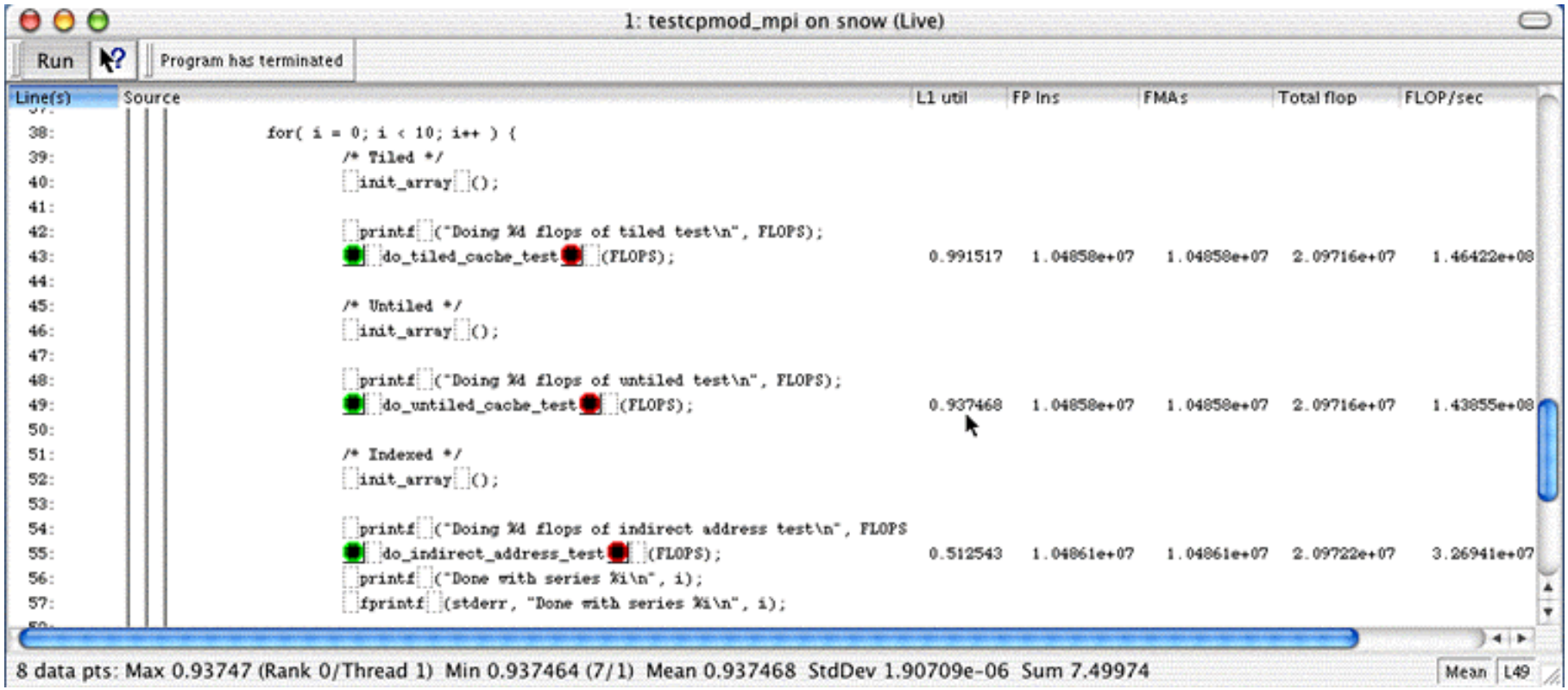
ToolGear Overview

- Dynamic instrumentation and analysis suite from LLNL
- Based on DPCL from IBM
  - Tested only on AIX
- Qt Front end can theoretically accept data from any source
- GUI displays instrumentable points
- Instrumented points update display with data in real time
- http://www.llnl.gov/CASC/tool_gear

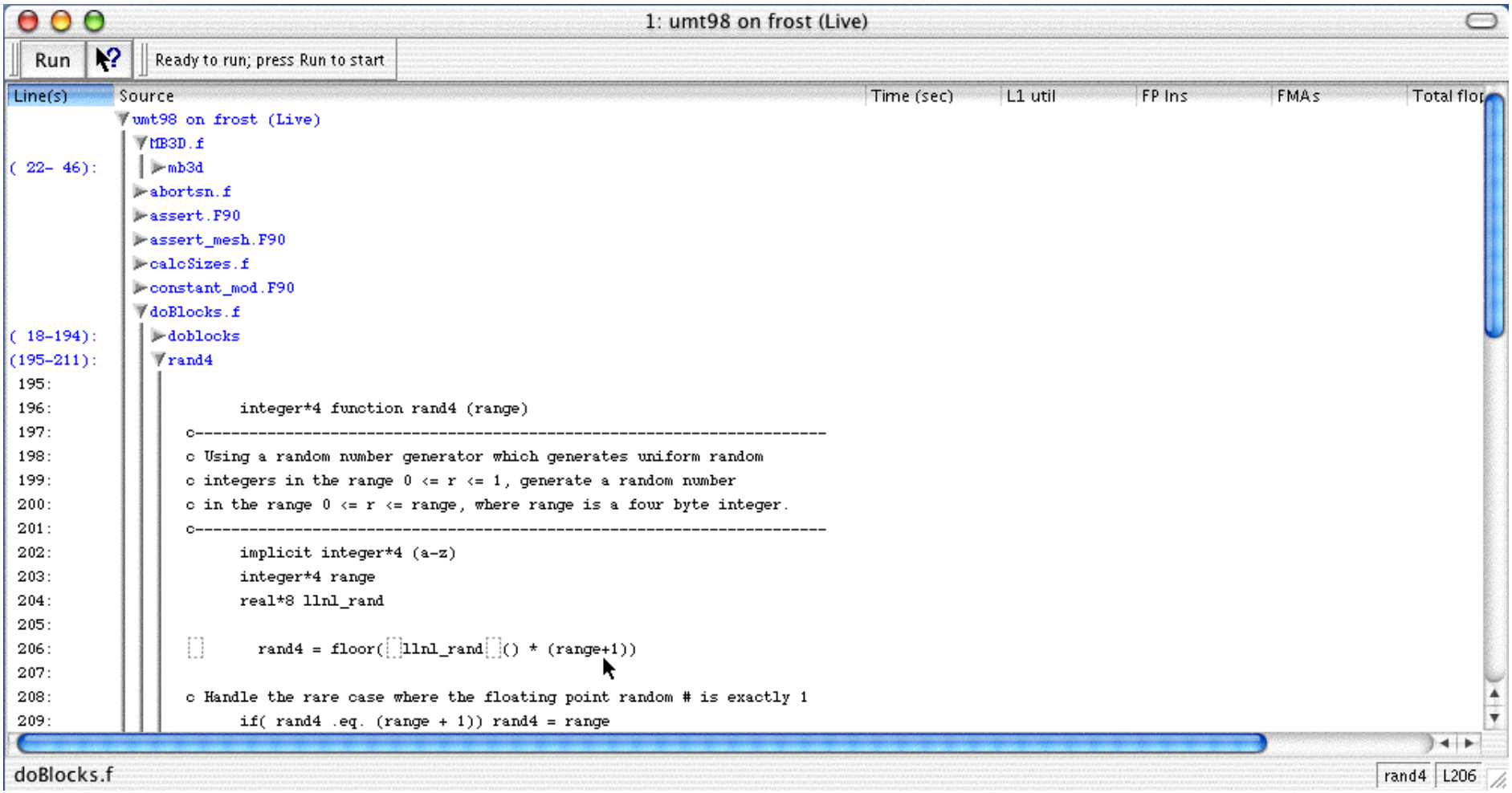
ToolGear Architecture



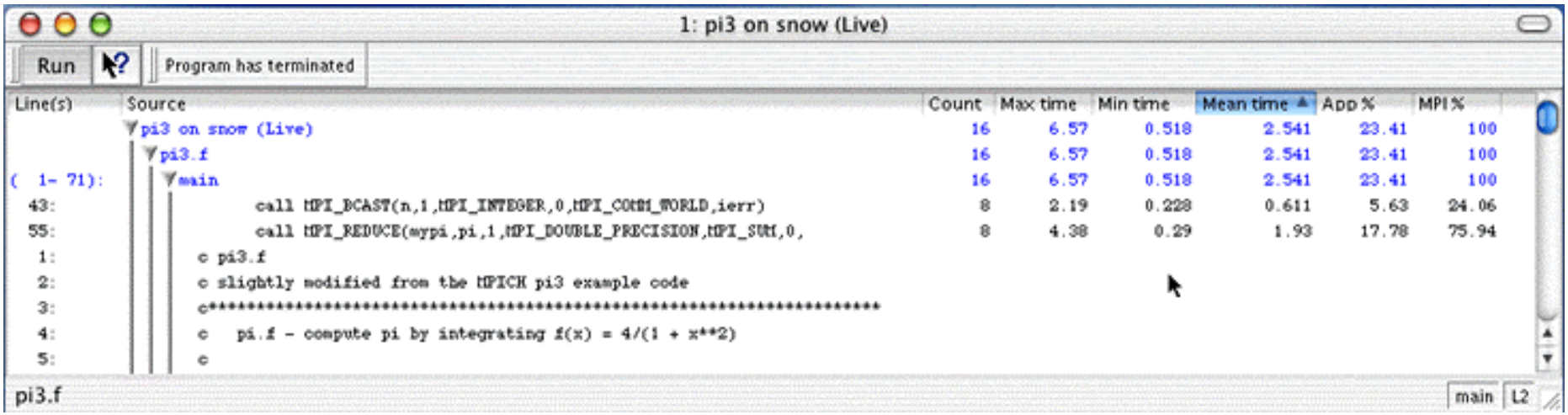
ToolGear Screenshot: Instrumentation



ToolGear Screenshot 2: Tree View



ToolGear Screenshot 3: MPI Profiling



DynaProf

- A portable tool to dynamically instrument serial and parallel programs for the purpose of performance analysis.
- Simple and intuitive command line interface like GDB.
- Java/Swing GUI.
- Instrumentation is done through the run-time insertion of function calls to specially developed performance probes.

Why the “Dyna” in DynaProf?

- Instrumentation:
  - Functions are contained in shared libraries.
  - Calls to those functions are generated at run-time.
  - Those calls are dynamically inserted into the program’s address space.
- Built on DynInst and DPCL
- Can choose the mode of instrumentation, currently:
  - Function Entry/Exit
  - Call site Entry/Exit
  - One-shot

DynaProf Goals

- Make collection of run-time performance data easy by:
  - Avoiding instrumentation and recompilation
  - Avoiding perturbation of compiler optimizations
  - Providing complete language independence
  - Allowing multiple insert/remove instrumentation cycles

No source code required!

DynaProf Goals 2

- Using the same tool with different probes
- Providing useful and meaningful probe data
- Providing different kinds of probes
- Allowing custom probe development Make collection of run-time performance data easy by:

No source code required!

Dynaprof Probes

- perfometerprobe
  - Visualize hardware event rates in “real-time”
- papiprobe
  - Measure any combination of PAPI presets and native events
- wallclockprobe
  - Highly accurate elapsed wallclock time in microseconds.
- The latter 2 probes report:
  - Inclusive
  - Exclusive
  - 1 Level Call Tree

DynaProf Probe Design

- Probes export a few functions with loosely standardized interfaces.
- Easy to roll your own.
  - If you can code a timer, you can write a probe.
- DynaProf detects thread model.
- Probes dictate how the data is recorded and visualized.

Threads and Dynaprof Probes

- For threaded code, use the same probe!
- Dynaprof detects threads and loads a special version of the probe library.
- Each probe specifies what to do when a new thread is discovered.
- Each thread gets the same instrumentation.

PAPI Probe

- Can count any PAPI preset or Native event accessible through PAPI
- Can count multiple events
- Supports PAPI multiplexing
- Supports multithreading
  - AIX: SMP, OpenMP, Pthreads
  - Linux: SMP, OpenMP, Pthreads

Wallclock Probe

- Counts microseconds using RTC
- Supports multithreading
  - AIX: SMP, OpenMP, Pthreads
  - Linux: SMP, OpenMP, Pthreads

Reporting Probe Data

- The wallclock and PAPI probes produce very similar data.
- Both use a parsing script written in Perl.
  - wallclockrpt <file>
  - papiproberpt <file>
- Produce 3 profiles
  - Inclusive: $T_{function} = T_{self} + T_{children}$
  - Exclusive: $T_{function} = T_{self}$
  - 1-Level Call Tree: $T_{child} = Inclusive\ T_{function}$

Sample DynaProf Session

```
$./dynaprof
(dynaprof) load tests/swim
(dynaprof) list
DEFAULT_MODULE
swim.F
libm.so.6
libc.so.6
(dynaprof) list swim.F
MAIN__
inital_
calc1_
calc2_
calc3z_
calc3_
(dynaprof) list swim.F MAIN__
Entry
    Call s_wsle
    Call do_lio
    Call e_wsle
    Call s_wsle
    Call do_lio
    Call e_wsle
    Call calc3_
```

```
(dynaprof) use probes/papiprobe
Module papiprobe.so was loaded.
Module libpapi.so was loaded.
Module libperfctr.so was loaded.
(dynaprof) instr module swim.F calc*
swim.F, inserted 4 instrumentation points
(dynaprof) run
papiprobe: output goes to
/home/mucci/dynaprof/tests/swim.1671
```

Instrumenting SWIM for IPC

```
(dynaprof) use probes/papiprobe PAPI_TOT_CYC, PAPI_TOT_INS
Module papiprobe.so was loaded.
Module libpapi.so was loaded.
Module libperfctr.so was loaded.
(dynaprof) instr function swim.F calc*
Swim.F, inserted 3 instrumentation points
(dynaprof) instr
calc1_
calc2_
calc3_
calc3z_
```

Swim Benchmark: Cycles & Instructions

Exclusive Profile of Metric PAPI_TOT_INS.

Name	Percent	Total	Calls
TOTAL	100	1.723e+09	1
calc2	38.28	6.598e+08	120
calc1	32.31	5.567e+08	120
calc3	22.33	3.847e+08	118
unknown	7.084	1.221e+08	1

Inclusive Profile of Metric PAPI_TOT_INS.

Name	Percent	Total	SubCalls
TOTAL	100	1.723e+09	0
calc2	39.42	6.793e+08	1680
calc1	35.28	6.08e+08	1800
calc3	22.87	3.942e+08	1652

1-Level Inclusive Call Tree of Metric PAPI_TOT_INS.

Parent/-Child	Percent	Total	Calls
TOTAL	100	1.723e+09	1
calc1	100	6.08e+08	120
- fsav	0.02065	1.255e+05	120
- mpi_irecv	0.03132	1.904e+05	120
- mpi_isend	0.05911	3.593e+05	120
- mpi_isend	0.06434	3.912e+05	120
-mpi_waitall	0.9013	5.479e+06	120
- mpi_irecv	0.03132	1.904e+05	120
- mpi_irecv	0.03132	1.904e+05	120
- mpi_isend	0.05356	3.256e+05	120
- mpi_isend	0.05079	3.088e+05	120
-mpi_waitall	6.813	4.142e+07	120
- mpi_irecv	0.03132	1.904e+05	120
- mpi_irecv	0.03132	1.904e+05	120
- mpi_isend	0.07504	4.562e+05	120
- mpi_isend	0.06757	4.108e+05	120
-mpi_waitall	0.161	9.791e+05	120
.al.2	100	6.793e+08	120

Exclusive Profile of Metric PAPI_TOT_CYC.

Name	Percent	Total	Calls
TOTAL	100	3.181e+09	1
calc2	34.85	1.108e+09	120
calc1	33.48	1.065e+09	120
calc3	26.1	8.301e+08	118
unknown	5.568	1.771e+08	1

Inclusive Profile of Metric PAPI_TOT_CYC.

Name	Percent	Total	SubCalls
TOTAL	100	3.181e+09	0
calc2	35.98	1.144e+09	1680
calc1	35.61	1.133e+09	1800
calc3	26.88	8.55e+08	1652

1-Level Inclusive Call Tree of Metric PAPI_TOT_CYC.

Parent/-Child	Percent	Total	Calls
TOTAL	100	3.181e+09	1
calc1	100	1.133e+09	120
- fsav	0.03432	3.887e+05	120
- mpi_irecv	0.07356	8.332e+05	120
- mpi_isend	0.0663	7.51e+05	120
- mpi_isend	0.0739	8.371e+05	120
-mpi_waitall	0.7189	8.143e+06	120
- mpi_irecv	0.1646	1.864e+06	120
- mpi_irecv	0.03407	3.859e+05	120
- mpi_isend	0.1867	2.115e+06	120
- mpi_isend	0.06067	6.872e+05	120
-mpi_waitall	4.22	4.78e+07	120
- mpi_irecv	0.03979	4.506e+05	120
- mpi_irecv	0.03008	3.407e+05	120
- mpi_isend	0.1014	1.148e+06	120
- mpi_isend	0.07568	8.573e+05	120
-mpi_waitall	0.1076	1.219e+06	120
.al.2	100	1.144e+09	120

Swim Benchmark: Instructions per Cycle

Exclusive Profile of Metric PAPI_TOT_INS.

Name	Percent	Total	Calls
TOTAL	100	1.723e+09	1
calc2	38.28	6.598e+08	120
calc1	32.31	5.567e+08	120
calc3	22.33	3.847e+08	118
unknown	7.084	[illegible]	1

Exclusive Profile of Metric PAPI_TOT_CYC.

Name	Percent	Total	Calls
TOTAL	100	3.181e+09	1
calc2	34.85	1.108e+09	120
calc1	33.48	1.06[illegible]09	120
calc3	26.1	8.301e+08	118
unknown	5.568	[illegible]	1

Inclusive Profile of Metric PAPI_TOT_INS.

Name	Percent	Total	SubCalls
TOTAL	100	1.723e+09	0
calc2	39.42	6.793e+08	1680
calc1	35.28	6.08e+08	1800
calc3	22.87	3.942e+08	

Inclusive Profile of Metric PAPI_TOT_CYC.

Name	Percent	Total	SubCalls
TOTAL	100	3.181e+09	0
calc2	35.98	1.144e+09	1680
calc1	35.61	1.133e+09	1800
[illegible]	26.88	8.55e+08	1652

1-Level Inclusive Call Tree of Metric PAPI_TOT_INS.

Parent/-Child	Percent	Total	Calls
TOTAL	100	1.7[illegible]	
calc1	100	6.[illegible]	
- fsav	0.02065	1[illegible]	
- mpi_irecv	0.03132	1[illegible]	
- mpi_isend	0.05911	3[illegible]	
- mpi_isend	0.06434	3[illegible]	
-mpi_waitall	0.9013	5[illegible]	
- mpi_irecv	0.03132	1[illegible]	
- mpi_irecv	0.03132	1.[illegible]	
- mpi_isend	0.05356	3.[illegible]	
- mpi_isend	0.05079	3.0[illegible]	
-mpi_waitall	6.813	4.142[illegible]	
- mpi_irecv	0.03132	1.904e[illegible]	
- mpi_irecv	0.03132	1.904e+0[illegible]	
- mpi_isend	0.07504	4.562e+05	
- mpi_isend	0.06757	4.108e+05	
-mpi_waitall	0.161	9.791e+05	

1-Level Inclusive Call Tree of Metric PAPI_TOT_CYC.

Parent/-Child	Percent	Total	Calls
TOTAL	[illegible]	3.181e+09	1
calc1	[illegible]	1.133e+09	120
- fsav	[illegible]2	3.887e+05	120
- mpi_irecv	[illegible]5	8.332e+05	120
- mpi_isend	[illegible]	7.51e+05	120
- mpi_isend	[illegible]	8.371e+05	120
-mpi_waitall	[illegible]	8.143e+06	120
- mpi_irecv	[illegible]	1.864e+06	120
- mpi_irecv	[illegible]7	3.859e+05	120
- mpi_isend	[illegible]	2.115e+06	120
- mpi_isend	[illegible]067	6.872e+05	120
-mpi_waitall	[illegible]2	4.78e+07	120
- mpi_irecv	[illegible]03979	4.506e+05	120
- mpi_irecv	[illegible]0.03008	3.407e+05	120
- mpi_isend	[illegible]0.1014	1.148e+06	120
- mpi_isend	[illegible]0.07568	8.573e+05	120
-mpi_waitall	[illegible]0.1076	1.219e+06	120

calc2	0.59
calc1	0.53
calc3	0.46

DynaProf GUI

- Displays module tree for instrumentation
- Simple selection of probes and instrumentation points
- Single-click execution of common DynaProf commands
- Coupling of probes and visualizers (e.g. Perfometer)

Dynaprof Status

- It's a bit rough
- Supported Platforms
  - Using DynInst 3.0
    - Linux 2.x
    - AIX 4.3/5
  - Using DPCL (formal MPI support)
    - AIX 4.3
    - AIX 5
- Includes:
  - Java/Swing GUI
  - User's Guide
  - Probe libraries
- Available as a development snapshot from:

http://www.cs.utk.edu/~mucci/dynaprof

The End

Thanks!

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