TAU

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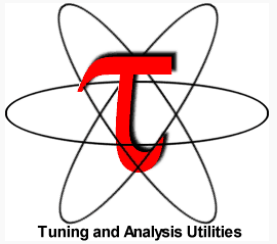
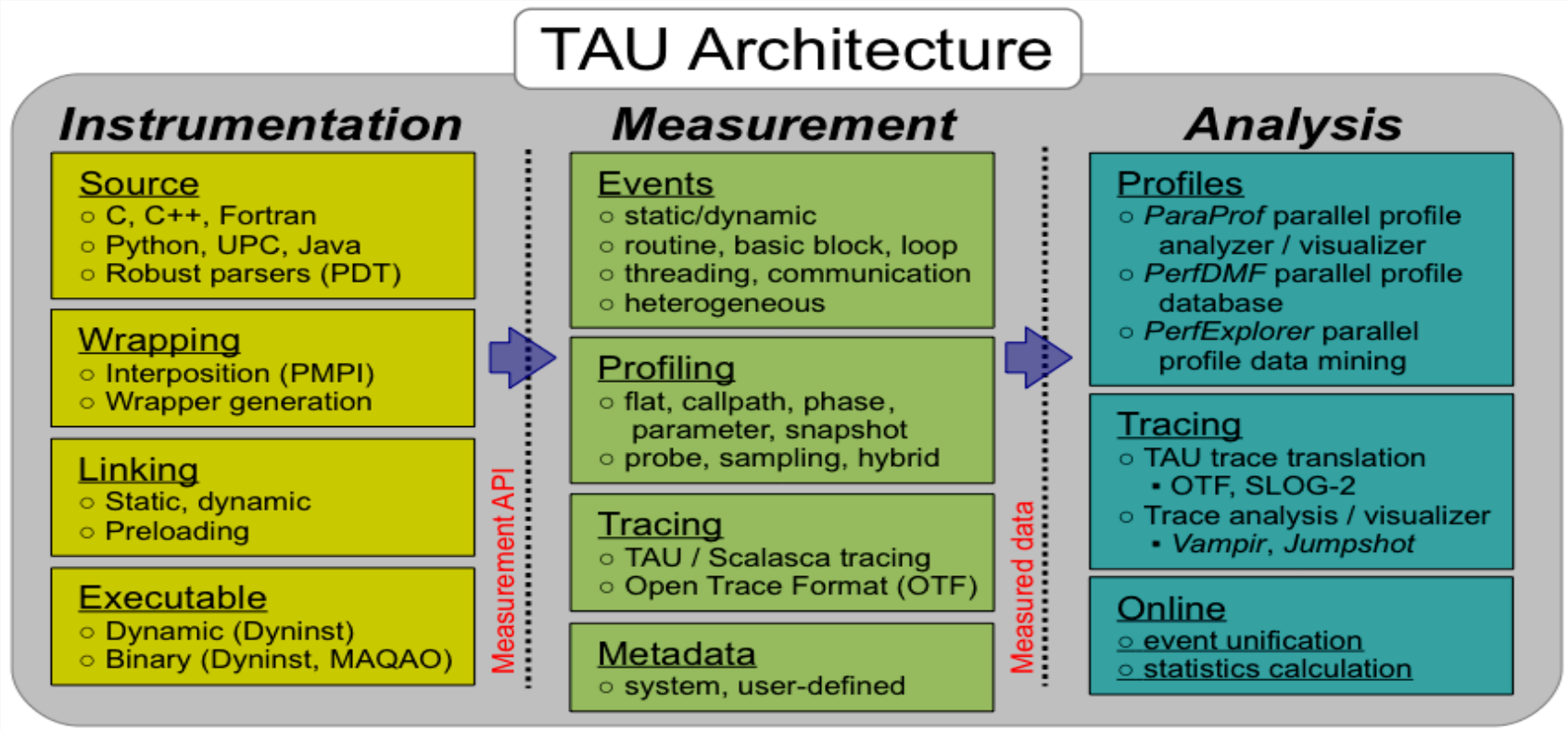
TAU Performance System®

Parallel performance framework and toolkit

- Supports all HPC platforms, compilers, runtime system
- Provides portable instrumentation, measurement, analysis





TAU Performance System

Instrumentation

– Fortran, C++, C, UPC, Java, Python, Chapel, Spark

– Automatic instrumentation

Measurement and analysis support

– MPI, OpenSHMEM, ARMCI, PGAS, DMAPP

– pthreads, OpenMP, OMPT interface, hybrid, other thread models

– GPU, CUDA, OpenCL, OpenACC

– Parallel profiling and tracing

– Use of Score-P for native OTF2 and CUBEX generation

Analysis

– Parallel profile analysis (ParaProf), data mining (PerfExplorer)

– Performance database technology (TAUdb)

– 3D profile browser

Application Performance Engineering using TAU

- How much time is spent in each application routine and outer *loops*? Within loops, what is the contribution of each *statement*? What is the time spent in OpenMP loops?
- How many instructions are executed in these code regions?
  Floating point, Level 1 and 2 *data cache misses*, hits, branches taken? What is the extent of vectorization for loops on Intel MIC?
- What is the memory usage of the code? When and where is memory allocated/de-allocated? Are there any memory leaks? What is the memory footprint of the application? What is the memory high water mark?
- How much energy does the application use in Joules? What is the peak power usage?
- What are the I/O characteristics of the code? What is the peak read and write *bandwidth* of individual calls, total volume?
- What is the contribution of each *phase* of the program? What is the time wasted/spent waiting for collectives, and I/O operations in Initialization, Computation, I/O phases?
- How does the application *scale*? What is the efficiency, runtime breakdown of performance across different core counts?

Instrumentation

Add hooks in the code to perform measurements

Source instrumentation using a preprocessor

– Add timer start/stop calls in a copy of the source code.
– Use Program Database Toolkit (PDT) for parsing source code.
– Requires recompiling the code using TAU shell scripts (tau_cc.sh, tau_f90.sh)
– Selective instrumentation (filter file) can reduce runtime overhead and narrow instrumentation focus.

Compiler-based instrumentation

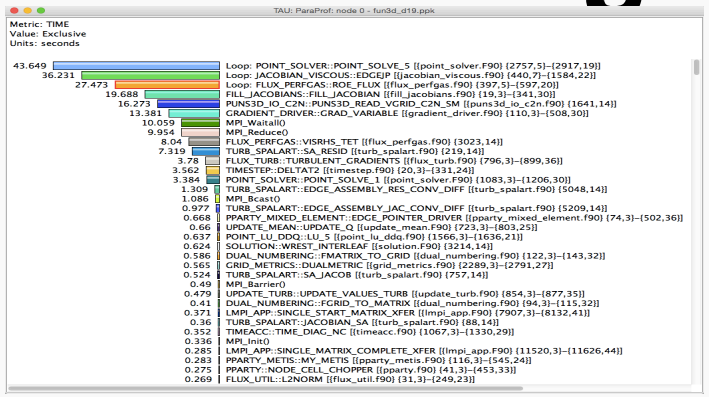
– Use system compiler to add a special flag to insert hooks at routine entry/exit.
– Requires recompiling using TAU compiler scripts (tau_cc.sh, tau_f90.sh…)

Runtime preloading of TAU's Dynamic Shared Object (DSO)

– No need to recompile code! Use **aprun tau_exec ./app** with options.
– Requires dynamic executable (link using **–dynamic** on Theta).

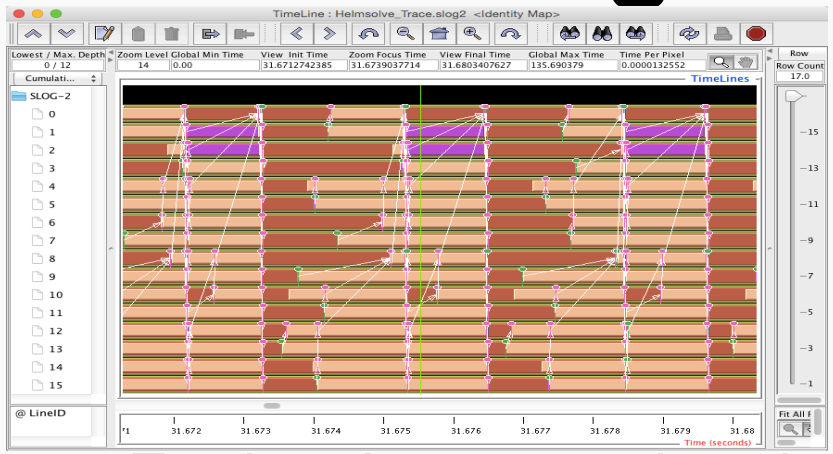
Profiling and Tracing

Profiling



- **Profiling** shows you **how much** (total) time was spent in each routine

Tracing



- Tracing shows you when the events take place on a timeline

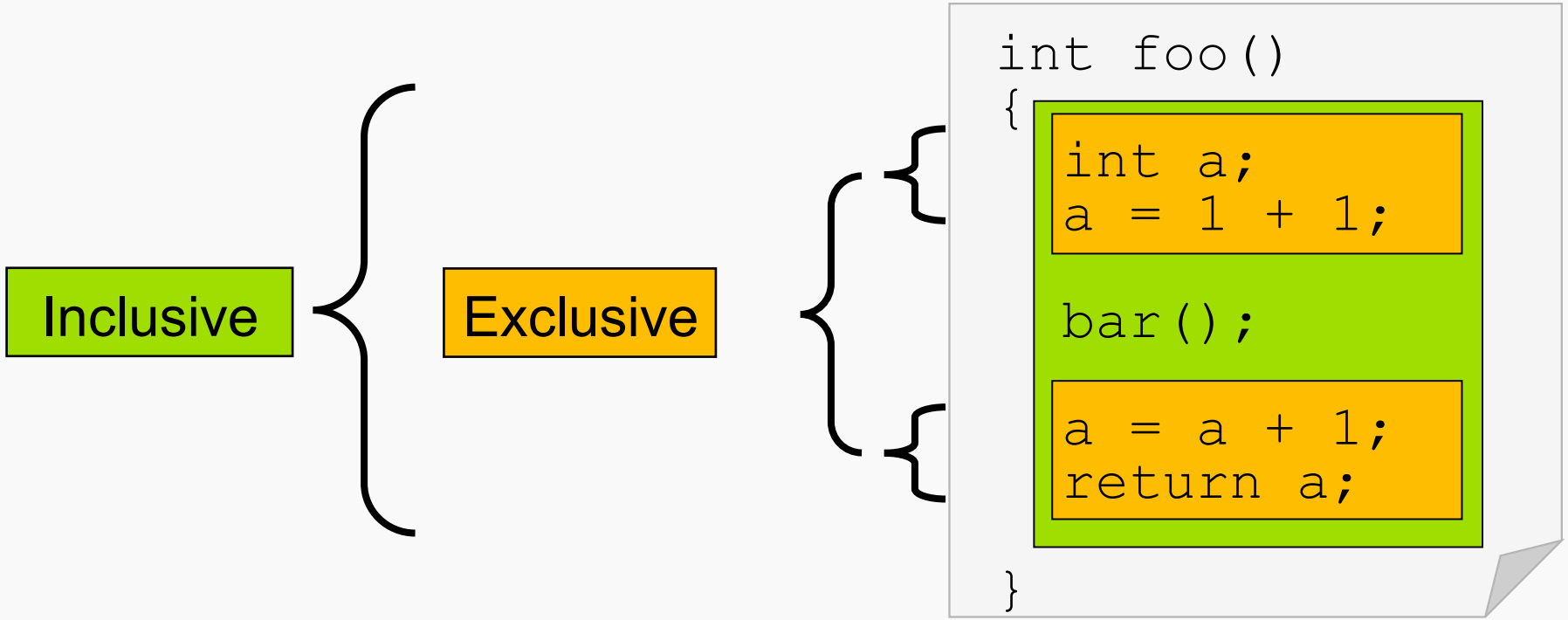
- Profiling and tracing

  Profiling shows you **how much** (total) time was spent in each routine

  Tracing shows you **when** the events take place on a timeline

Inclusive vs. Exclusive values

- Inclusive
  - Information of all sub-elements aggregated into single value
- Exclusive
  - Information cannot be subdivided further



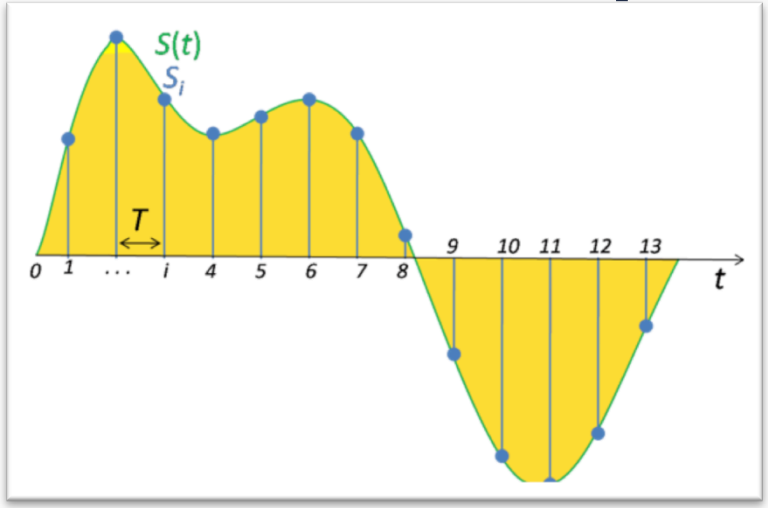
Performance Data Measurement

Direct via Probes

```
Call
START('potential')
// code
Call
STOP('potential')
```

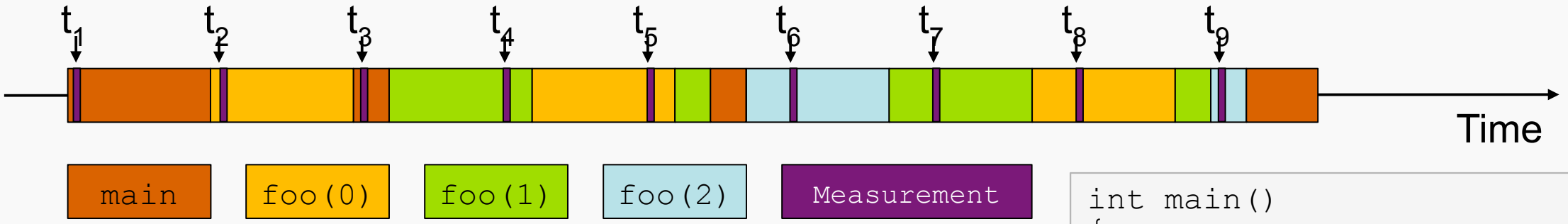
- Exact measurement
- Fine-grain control
- Calls inserted into code

Indirect via Sampling



- No code modification
- Minimal effort
- Relies on debug symbols (**-g**)

Sampling



Running program is periodically interrupted to take measurement

– Timer interrupt, OS signal, or HWC overflow
– Service routine examines return-address stack
– Addresses are mapped to routines using symbol table information

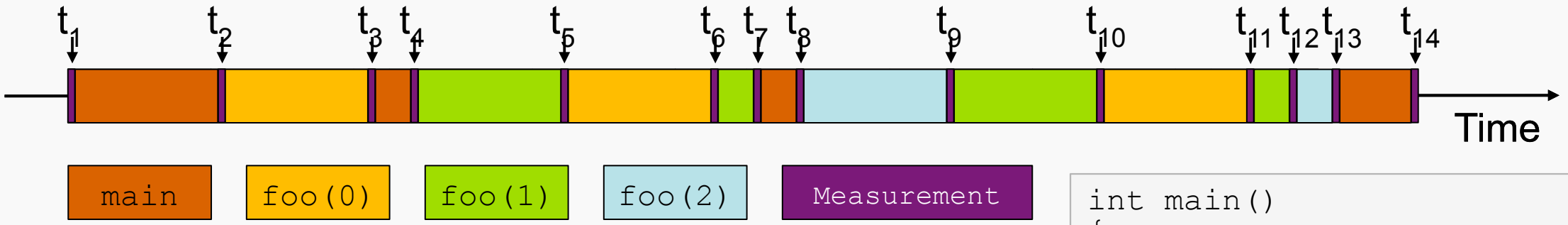
Statistical inference of program behavior

– Not very detailed information on highly volatile metrics
– Requires long-running applications

Works with unmodified executables

```
int main()
{
  int i;

  for (i=0; i < 3; i++)
    foo(i);

  return 0;
}

void foo(int i)
{

  if (i > 0)
    foo(i - 1);

}
```

Instrumentation



Measurement code is inserted such that every event of interest is captured directly

– Can be done in various ways

Advantage:

– Much more detailed information

Disadvantage:

– Processing of source-code / executable necessary
– Large relative overheads for small functions

```
int main()
{
  int i;
  Start("main");
  for (i=0; i < 3; i++)
    foo(i);
  Stop ("main");
  return 0;
}

void foo(int i)
{
  Start("foo");
  if (i > 0)
    foo(i - 1);
  Stop ("foo");
}
```

Using TAU's Runtime Preloading Tool: tau_exec

Preload a wrapper that intercepts the runtime system call and substitutes with another

- **MPI**
- **OpenMP**
- **POSIX I/O**
- **Memory allocation/deallocation routines**
- **Wrapper library for an external package**

No modification to the binary executable!

Enable other TAU options (communication matrix, OTF2, event-based sampling)


DEMO

Simplifying TAU's usage (tau_exec)

Uninstrumented execution
- % aprun -n 64 ./a.out

Track MPI performance
- % aprun -n 64 tau_exec ./a.out

Use event based sampling (compile with –g)
- % aprun -n 64 tau_exec –ebs ./a.out
- Also –ebs_source=<PAPI_COUNTER> -ebs_period=<overflow_count>

Track POSIX I/O and MPI performance (MPI enabled by default)
- % aprun -n 64 tau_exec –T mpi,pdt,papi –io ./a.out

Track OpenMP runtime routines

% export TAU_OMPT_SUPPORT_LEVEL=full; export TAU_OMPT_RESOLVE_ADDRESS_EAGERLY=1
- % aprun –n 64 tau_exec –T ompt,tr6,pdt,mpi –ompt ./a.out

Track memory operations
- % export TAU_TRACK_MEMORY_LEAKS=1
- % aprun -n 64 tau_exec –memory_debug ./a.out (bounds check)

Load wrapper interposition library
- % aprun –n 64 tau_exec –loadlib=<path/libwrapper.so> ./a.out

RUNTIME PRELOADING

Injects TAU DSO in the executing application

Requires dynamic executables

We must compile with -dynamic -g

Use tau_exec while launching the application

Copy the workshop tarball

Setup preferred program environment compilers

– Default set Intel Compilers with Intel MPI. You must compile with **–dynamic -g**

```
% mkdir /lus/theta-fs0/projects/Comp_Perf_Workshop/$USER
% cd !$; tar zxf /soft/perftools/tau/workshop.tgz
% module load tau
% cd MZ-NPB3.3-MPI; cat README
% make clean
% make suite
% cd bin
In a second window:
% qsub -I -n 1 -A <Account> -t 50
% cd bin; module unload darshan; module load intel; module load tau
% export OMP_NUM_THREADS=4
% aprun –n 16 ./bt-mz.B.16
% export TAU_OMPT_SUPPORT_LEVEL=full; export TAU_OMPT_RESOLVE_ADDRESS_EAGERLY=1
% aprun –n 16 tau_exec –T ompt,mpi,pdt –ompt ./bt-mz.B.16
% paraprof --pack ex1.ppk
In the first window:
% paraprof ex1.ppk &
```

NPB-MZ-MPI Suite

The NAS Parallel Benchmark suite (MPI+OpenMP version)

– Available from:

http://www.nas.nasa.gov/Software/NPB

– 3 benchmarks in Fortran77

– Configurable for various sizes & classes

Move into the NPB3.3-MZ-MPI root directory

Subdirectories contain source code for each benchmark

– plus additional configuration and common code

```
% ls
bin/    common/  jobscript/  Makefile  README.install   SP-MZ/
BT-MZ/  config/  LU-MZ/      README    README.tutorial  sys/
```

of the

NPB-MZ-MPI / BT (Block Tridiagonal Solver)

What does it do?

– Solves a discretized version of the unsteady, compressible Navier-Stokes equations in three spatial dimensions
– Performs 200 time-steps on a regular 3-dimensional grid

Implemented in 20 or so Fortran77 source modules

Uses MPI & OpenMP in combination

– 16 processes each with 4 threads should be reasonable

– bt-mz.B.16 should take around 1 minute

NPB-MZ-MPI / BT: config/make.def

```
#                SITE- AND/OR PLATFORM-SPECIFIC DEFINITIONS.
#
#---------------------------------------------------------------------

#---------------------------------------------------------------------
# Configured for generic MPI with GCC compiler
#---------------------------------------------------------------------
#OPENMP  = -fopenmp      # GCC compiler
OPENMP = -qopenmp -extend-source        # Intel compiler

...
#---------------------------------------------------------------------
# The Fortran compiler used for MPI programs
#---------------------------------------------------------------------

F77 = ftn # Intel compiler

# Alternative variant to perform instrumentation

...
```

Default (no instrumentation)

Building an NPB-MZ-MPI Benchmark

```
% make
  ============================================
  =      NAS PARALLEL BENCHMARKS 3.3         =
  =      MPI+OpenMP Multi-Zone Versions      =
  =      F77                                 =
  ============================================

  To make a NAS multi-zone benchmark type

        make <benchmark-name> CLASS=<class> NPROCS=<nprocs>

  where <benchmark-name> is "bt-mz", "lu-mz", or "sp-mz"
        <class>          is "S", "W", "A" through "F"
        <nprocs>         is number of processes

  [...]

 ***********************************************************
 * Custom build configuration is specified in config/make.def  *
 * Suggested tutorial exercise configuration for HPC systems:  *
 *       make bt-mz CLASS=C NPROCS=8                           *
 ***********************************************************
```

Type "make" for instructions

make suite

TAU Source Instrumentation

Edit config/make.def to adjust build configuration

– Uncomment specification of compiler/linker: F77 = tau_f77.sh or use
  make F77=tau_f77.sh

Make clean and build new tool-specific executable

Change to the directory containing the new executable before running it with the desired tool configuration

tau_exec

```
$ tau_exec

Usage: tau_exec [options] [--] <exe> <exe options>

Options:
        -v              Verbose mode
        -s              Show what will be done but don't actually do anything (dryrun)
        -qsub           Use qsub mode (BG/P only, see below)
        -io             Track I/O
        -memory         Track memory allocation/deallocation
        -memory_debug Enable memory debugger
        -cuda           Track GPU events via CUDA
        -cupti          Track GPU events via CUPTI (Also see env. variable TAU_CUPTI_API)
        -opencl         Track GPU events via OpenCL
        -openacc        Track GPU events via OpenACC (currently PGI only)
        -ompt           Track OpenMP events via OMPT interface
        -armci          Track ARMCI events via PARMCI
        -ebs            Enable event-based sampling
        -ebs_period=<count> Sampling period (default 1000)
        -ebs_source=<counter> Counter (default itimer)
        -um           Enable Unified Memory events via CUPTI
        -T <DISABLE,GNU,ICPC,MPI,OMPT,OPENMP,PAPI,PDT,PROFILE,PTHREAD,SCOREP,SERIAL> : Specify TAU tags
        -loadlib=<file.so>    : Specify additional load library
        -XrunTAUsh-<options> : Specify TAU library directly
        -gdb            Run program in the gdb debugger

Notes:
           Defaults if unspecified: -T MPI
           MPI is assumed unless SERIAL is specified
```

Tau_exec preloads the TAU wrapper libraries and performs measurements.

No need to recompile the application!

tau_exec Example (continued)

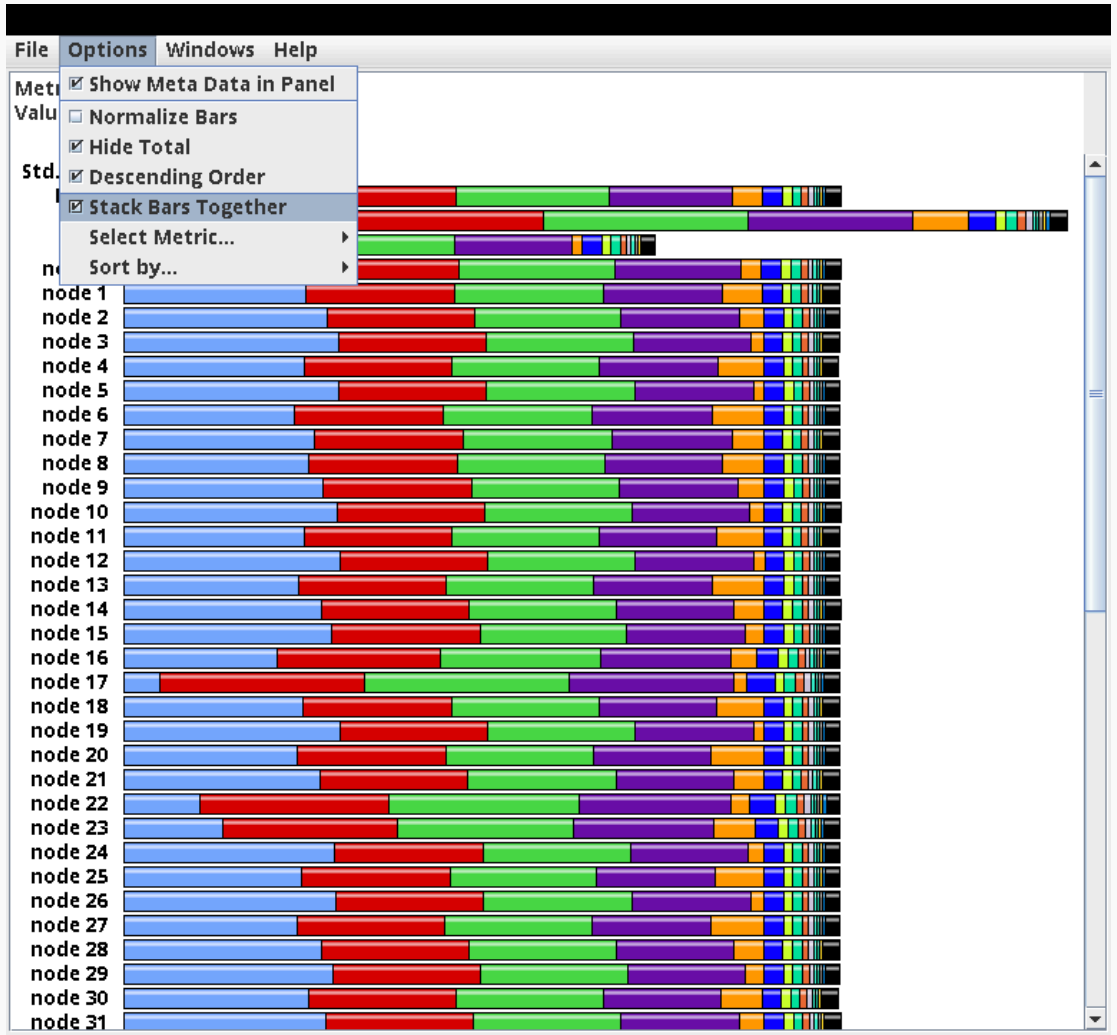
```
Example:
    mpirun -np 2 tau_exec -T icpc,ompt,mpi  -ompt ./a.out
    aprun -n  2 tau_exec -io ./a.out
Example - event-based sampling with samples taken every 1,000,000 FP instructions
    aprun -n  8 tau_exec -ebs -ebs_period=1000000 -ebs_source=PAPI_FP_INS ./ring
Examples - GPU:
    tau_exec -T serial,cupti -cupti ./matmult (Preferred for CUDA 4.1 or later)
    tau_exec -openacc ./a.out
    tau_exec -T serial -opencl ./a.out (OPENCL)
    mpirun -np 2 tau_exec -T mpi,cupti,papi -cupti -um ./a.out (Unified Virtual Memory in CUDA 6.0+)

qsub mode (IBM BG/Q only):
    Original:
      qsub -n 1 --mode smp -t 10 ./a.out
    With TAU:
      tau_exec -qsub -io -memory -- qsub -n 1 … -t 10 ./a.out

Memory Debugging:
    -memory option:
      Tracks heap allocation/deallocation and memory leaks.
    -memory_debug option:
      Detects memory leaks, checks for invalid alignment, and checks for
      array overflow.  This is exactly like setting TAU_TRACK_MEMORY_LEAKS=1
      and TAU_MEMDBG_PROTECT_ABOVE=1 and running with -memory
```

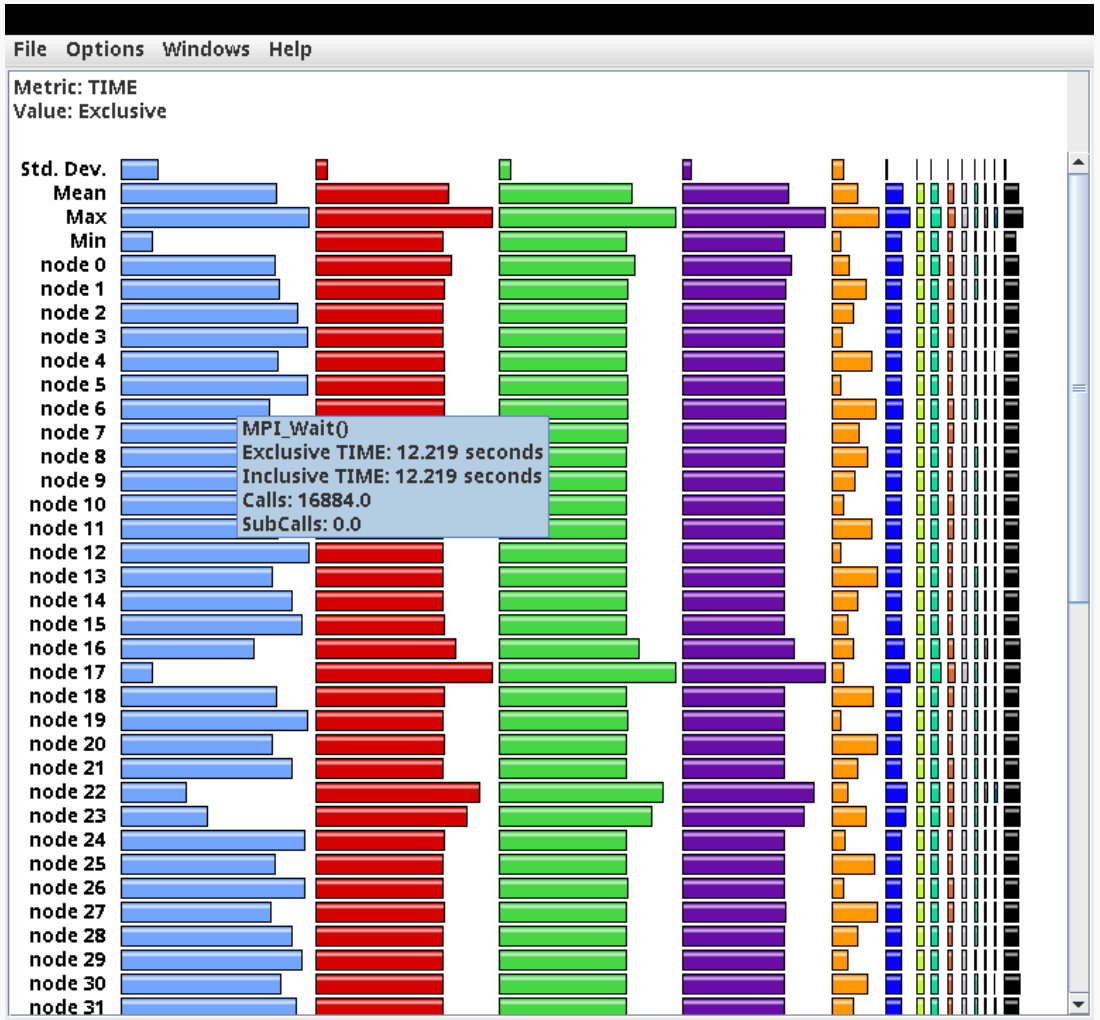
tau_exec can enable event based sampling while launching the executable using env TAU_SAMPLING=1 or tau_exec -ebs

ParaProf Profile Browser

```
% paraprof
```

ParaProf Profile Browser

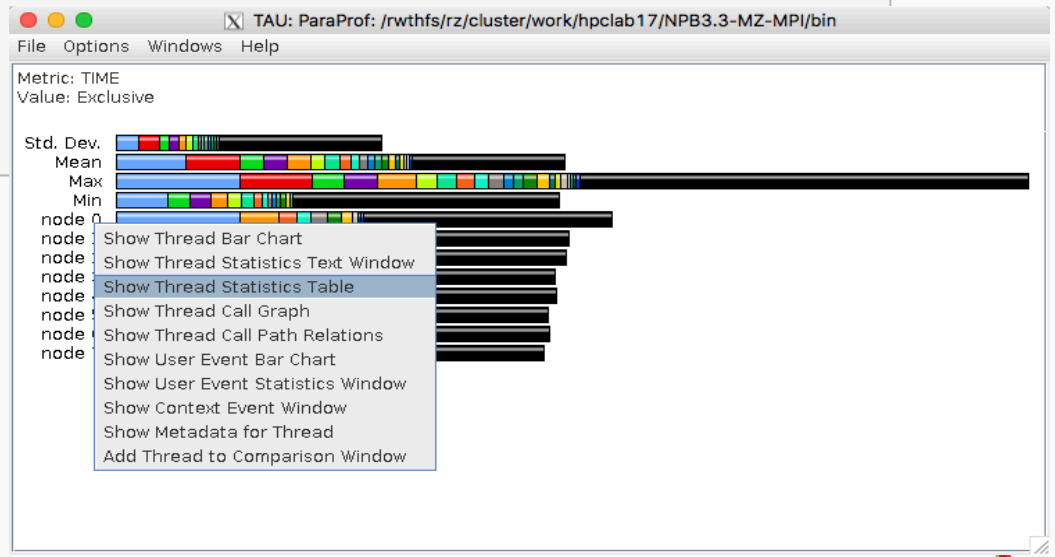




Event Based Sampling with TAU

Launch paraprof

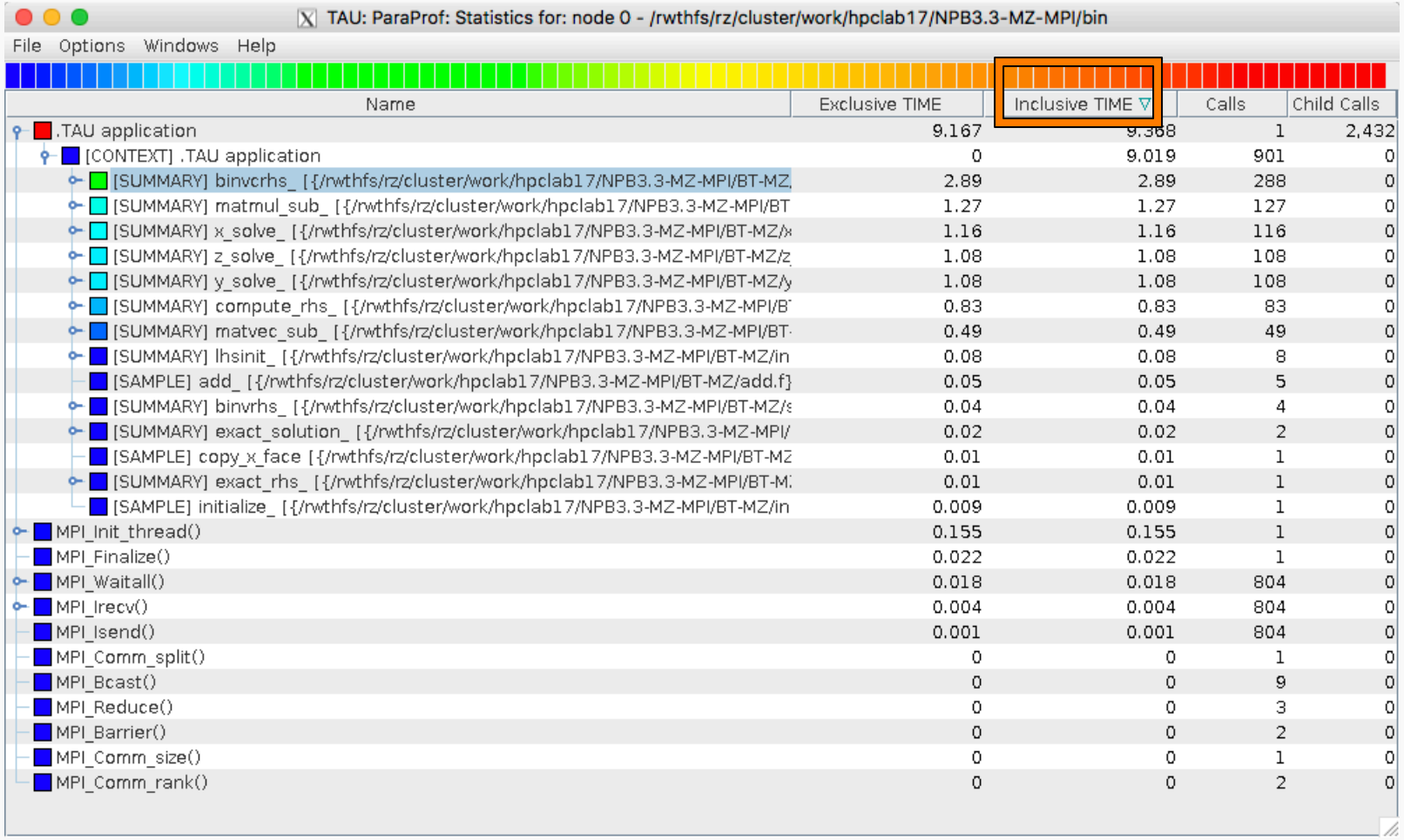
```
% cd MZ-NPB3.3-MPI; cat README
% make clean;
% make suite
% cd bin
% qsub -I -n 1 -A <Project>  -t 50 -q cache-quad
% module unload darshan; module load intel tau
% export OMP_NUM_THREADS=4
% export TAU_OMPT_SUPPORT_LEVEL=full; export TAU_OMPT_RESOLVE_ADDRESS_EAGERLY=1
% aprun -n 16 tau_exec -T ompt,tr6 -ebs ./bt-mz.B.16
% On head node:
% module load tau
% paraprof
```



ParaProf

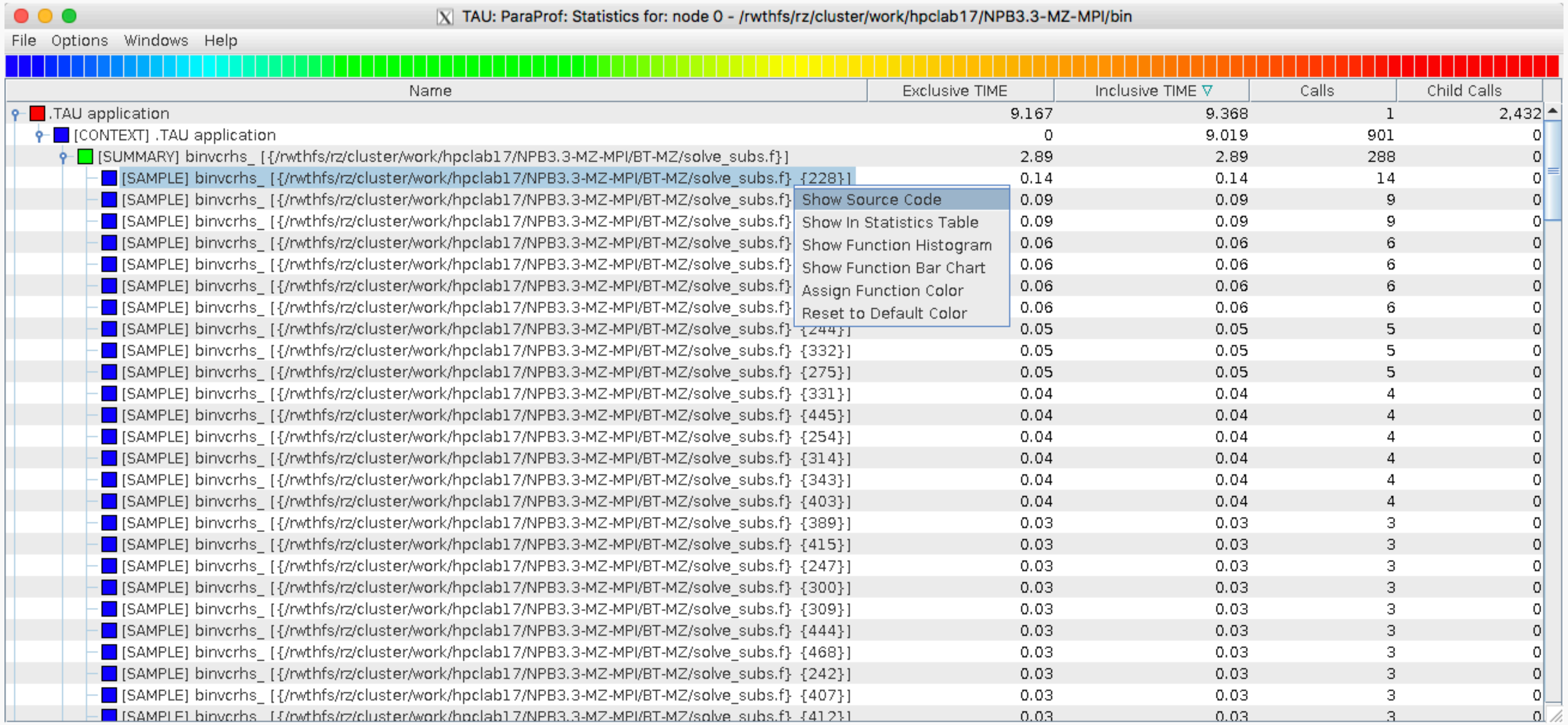
Click on Columns:
to sort by incl time

Open binvcrhs
Click on Sample



Name	Exclusive TIME	Inclusive TIME ▽	Calls	Child Calls
.TAU application	9.167	9.368	1	2,432
[CONTEXT] .TAU application	0	9.019	901	0
[SUMMARY] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ	2.89	2.89	288	0
[SUMMARY] matmul_sub_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT	1.27	1.27	127	0
[SUMMARY] x_solve_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/x	1.16	1.16	116	0
[SUMMARY] z_solve_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/z	1.08	1.08	108	0
[SUMMARY] y_solve_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/y	1.08	1.08	108	0
[SUMMARY] compute_rhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/B	0.83	0.83	83	0
[SUMMARY] matvec_sub_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT	0.49	0.49	49	0
[SUMMARY] lhsinit_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/in	0.08	0.08	8	0
[SAMPLE] add_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/add.f}	0.05	0.05	5	0
[SUMMARY] binvrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/s	0.04	0.04	4	0
[SUMMARY] exact_solution_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/	0.02	0.02	2	0
[SAMPLE] copy_x_face [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ	0.01	0.01	1	0
[SUMMARY] exact_rhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-M	0.01	0.01	1	0
[SAMPLE] initialize_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/in	0.009	0.009	1	0
MPI_Init_thread()	0.155	0.155	1	0
MPI_Finalize()	0.022	0.022	1	0
MPI_Waitall()	0.018	0.018	804	0
MPI_Irecv()	0.004	0.004	804	0
MPI_Isend()	0.001	0.001	804	0
MPI_Comm_split()	0	0	1	0
MPI_Bcast()	0	0	9	0
MPI_Reduce()	0	0	3	0
MPI_Barrier()	0	0	2	0
MPI_Comm_size()	0	0	1	0
MPI_Comm_rank()	0	0	2	0

ParaProf



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[CONTEXT] .TAU application	0	9.019	901	0
[SUMMARY] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}]	2.89	2.89	288	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {228}]	0.14	0.14	14	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.09	0.09	9	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.09	0.09	9	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.06	0.06	6	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.06	0.06	6	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.06	0.06	6	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f}	0.06	0.06	6	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {244}]	0.05	0.05	5	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {332}]	0.05	0.05	5	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {275}]	0.05	0.05	5	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {331}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {445}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {254}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {314}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {343}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {403}]	0.04	0.04	4	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {389}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {415}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {247}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {300}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {309}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {444}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {468}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {242}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {407}]	0.03	0.03	3	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {412}]	0.03	0.03	3	0

TAU_EBS_UNWIND=1, TAU_SAMPLING=1

TAU: ParaProf: Statistics for: n,c,t 2,0,0 - gamess_unw_call_ebs.ppk

Name	Inclusive TIME ▽	Calls
.TAU application	79.592	1
MPI_Recv()	75.607	6,870
[CONTEXT] MPI_Recv()	74.848	1,497
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN__ [{/gpfs/mira-home/sameer/gamess-theta-t	26.196	524
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sameer/ga	21.7	434
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-home/sameer/gamess-theta-ta	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yuri/dist/Gi	8.701	174
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_Init [{/gpfs/mira-home/yuri/dist/C	5.75	115
[UNWIND] /lib64/libc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu/../sysdeps/x86_64/start.S} {118}]	0.2	4
[SAMPLE] GNII_DlaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.2	4
[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNRESOLVED UNKNOWN	0.15	3
[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.051	1
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/7	0.05	1
MPI_Finalize()	3.601	1
MPI_Send()	0.122	6,866
MPI_Init_thread()	0.112	1
[CONTEXT] .TAU application	0.05	1
MPI_Bcast()	0.014	6
MPI_Allgather()	0.004	3
MPI_Barrier()	0.003	7
MPI_Comm_create()	0.002	4
MPI_Gather()	0.002	1
MPI_Comm_split()	0.002	1
MPI_Group_intersection()	0.001	1
MPI_Comm_group()	0.001	1
MPI_Group_incl()	0	3
MPI_Comm_rank()	0	6
MPI_Comm_size()	0	2

UNWINDING CALLSTACKS

Name	Inclusive TIME ▽	Calls
.TAU application	79.592	1
MPI_Recv()	75.607	6,870
[CONTEXT] MPI_Recv()	74.848	1,497
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN__ [{/gpfs/mira-home/sameer/gamess-theta-	26.196	524
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sameer/g	21.7	434
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yuri/dist	21.7	434
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_Init [{/gpfs/mira-home/yuri/	21.7	434
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_recv.c.65 [@] DDI_Server [{/gpfs/mira-home/y	21.7	434
[UNWIND] /lus/theta-fs0/software/perftools/tau/tau-2.26.3/src/Profile/TauMpi.c.2371 [@] DDI_Recv_request [{/gpfs/mira	21.7	434
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPI_Recv [{/lus/theta-fs0/sof	21.7	434
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] PMPI_Recv [{/opt/cray/pe/n	21.7	434
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPIDI_CH3I_Progress [{/	21.45	429
[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0 [@] MPID_nem_gni_poll [{/	15.95	319
[SAMPLE] GNI_SmsgGetNextWTag [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0}	10.349	207
[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	5.6	112
[UNWIND] gni_poll.c.0 [@] MPID_nem_gni_poll [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_inte	5.25	105
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPID_nem_gni_poll [{/	0.25	5
[UNWIND] UNRESOLVED [@] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_int	0.25	5
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-home/sameer/gamess-theta-ta	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yuri/dist/G	8.701	174
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_Init [{/gpfs/mira-home/yuri/dist/	5.75	115
[UNWIND] /lib64/libc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu/../sysdeps/x86_64/start.S} {118}]	0.2	4
[SAMPLE] GNII_DlaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.2	4
[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNRESOLVED UNKNOWN	0.15	3
[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.051	1
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/	0.05	1
MPI_Finalize()	3.601	1
MPI_Send()	0.122	6,866
MPI_Init_thread()	0.112	1
[CONTEXT] .TAU application	0.05	1

UNWINDING CALLSTACKS

TAU: ParaProf: Statistics for: n,c,t 2,0,0 - gamess_unw_call_ebs.ppk

Name	Inclusive TIME ▽	Calls
.TAU application	79.592	1
MPI_Recv()	75.607	6,870
[CONTEXT] MPI_Recv()	74.848	1,497
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN__ [{/gpfs/mira-home/sameer/gamess-theta-	26.196	524
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sameer/g	21.7	434
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-home/sameer/gamess-theta-ta	11.85	237
[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN__ [{/gpfs/mira-home/sameer/gamess-thet	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sam	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yur	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_Init [{/gpfs/mira-home/	11.85	237
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_recv.c.65 [@] DDI_Server [{/gpfs/mira-ho	11.85	237
[UNWIND] /lus/theta-fs0/software/perftools/tau/tau-2.26.3/src/Profile/TauMpi.c.2371 [@] DDI_Recv_request [{/gpfs	11.85	237
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPI_Recv [{/lus/theta-fs(	11.85	237
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] PMPI_Recv [{/opt/cray/	11.7	234
[SAMPLE] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1} {0	11.3	226
[SAMPLE] MPIDU_Sched_are_pending [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0	0.2	4
[SAMPLE] MPID_nem_gni_poll [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1} {0}]	0.15	3
[SAMPLE] MPID_nem_network_poll [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1	0.05	1
[UNWIND] ch3_progress.c.0 [@] PMPI_Recv [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.	0.15	3
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yuri/dist/G	8.701	174
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_Init [{/gpfs/mira-home/yuri/dist/	5.75	115
[UNWIND] /lib64/libc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu/../sysdeps/x86_64/start.S} {118}]	0.2	4
[SAMPLE] GNII_DlaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.2	4
[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNRESOLVED UNKNOWN	0.15	3
[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.051	1
[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/	0.05	1
MPI_Finalize()	3.601	1
MPI_Send()	0.122	6,866
MPI_Init_thread()	0.112	1
[CONTEXT] .TAU application	0.05	1

CALLPATH THREAD RELATIONS WINDOW

TAU: ParaProf: Call Path Data n,c,t, 2,0,0 - gamess_unw_call_ebs.ppk

Metric Name: TIME
Sorted By: Inclusive
Units: seconds

	Exclusive	Inclusive	Calls/Tot.Calls	Name[id]
-->	0.121	79.592	1	.TAU application
	0.002	0.002	1/1	MPI_Gather()
	0.004	0.004	3/3	MPI_Allgather()
	0.122	0.122	6866/6866	MPI_Send()
	0.002	0.002	1/1	MPI_Comm_split()
	8.9E-5	8.9E-5	2/2	MPI_Comm_size()
	4.6E-4	4.6E-4	3/3	MPI_Group_incl()
	75.607	75.607	6870/6870	MPI_Recv()
	0.002	0.002	4/4	MPI_Comm_create()
	9.5E-5	9.5E-5	6/6	MPI_Comm_rank()
	5.4E-4	5.4E-4	1/1	MPI_Comm_group()
	0.003	0.003	7/7	MPI_Barrier()
	0.112	0.112	1/1	MPI_Init_thread()
	6.3E-4	6.3E-4	1/1	MPI_Group_intersection()
	0	0.05	1/1	[CONTEXT] .TAU application
	3.601	3.601	1/1	MPI_Finalize()
	0.014	0.014	6/6	MPI_Bcast()
	75.607	75.607	6870/6870	.TAU application
-->	75.607	75.607	6870	MPI_Recv()
	0	74.848	1497/1497	[CONTEXT] MPI_Recv()
	0	74.848	1497/1497	MPI_Recv()
-->	0	74.848	1497	[CONTEXT] MPI_Recv()
	0	8.701	174/1371	[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_i
	0	26.196	524/763	[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN__ [{/gpfs/mir
	0.2	0.2	4/138	[SAMPLE] GNII_DlaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.s
	0	5.75	115/1484	[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_server.c.99 [@] DDI_
	0	0.2	4/5	[UNWIND] /lib64/libc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu/../s
	0	11.85	237/239	[UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-
	0.051	0.051	1/273	[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so
	0	0.05	1/1197	[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPID
	0	0.15	3/7	[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNI
	0	21.7	434/1197	[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beg

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CALLPATH THREAD RELATIONS WINDOW

TAU: ParaProf: Call Path Data n,c,t, 2,0,0 - gamess_unw_call_ebs.ppk

Metric Name: TIME
Sorted By: Exclusive
Units: seconds

	Exclusive	Inclusive	Calls/Tot.Calls	Name[id]
	75.607	75.607	6870/6870	.TAU application
-->	75.607	75.607	6870	MPI_Recv()
	0	74.848	1497/1497	[CONTEXT] MPI_Recv()
	0.15	0.15	3/444	[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] PMPI_Recv
	22.046	22.046	441/444	[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] MPIDI_CH3
-->	22.196	22.196	444	[SAMPLE] MPID_nem_gni_poll [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3
	5.6	5.6	112/273	[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0 [@] MPID_nem_
	0.051	0.051	1/273	[CONTEXT] MPI_Recv()
	7.651	7.651	153/273	[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0 [@] MPID_nem_
	0.35	0.35	7/273	[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNRESOL
-->	13.652	13.652	273	[SAMPLE] GNI_CqGetEvent [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.
	11.3	11.3	226/226	[UNWIND] /opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so.3.0.1.0 [@] PMPI_Recv
-->	11.3	11.3	226	[SAMPLE] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/libmpich_intel.so
	10.349	10.349	207/207	[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0 [@] MPID_nem_
-->	10.349	10.349	207	[SAMPLE] GNI_SmsgGetNextWTag [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so
	0.2	0.2	4/138	[CONTEXT] MPI_Recv()
	6.701	6.701	134/138	[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.6.0.0 [@] GNI_CqGet
-->	6.901	6.901	138	[SAMPLE] GNII_DlaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1__ge7db4a2.ari/lib64/libugni.so.0.
	5.25	5.25	105/109	[UNWIND] gni_poll.c.0 [@] MPID_nem_gni_poll [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/li
	0.2	0.2	4/109	[UNWIND] gni_poll.c.0 [@] MPIDI_CH3I_Progress [{/opt/cray/pe/mpt/7.6.3/gni/mpich-intel/16.0/lib/
-->	5.45	5.45	109	[SAMPLE] MPID_nem_gni_check_localCQ [{gni_poll.c} {0}]
	3.601	3.601	1/1	.TAU application
-->	3.601	3.601	1	MPI_Finalize()

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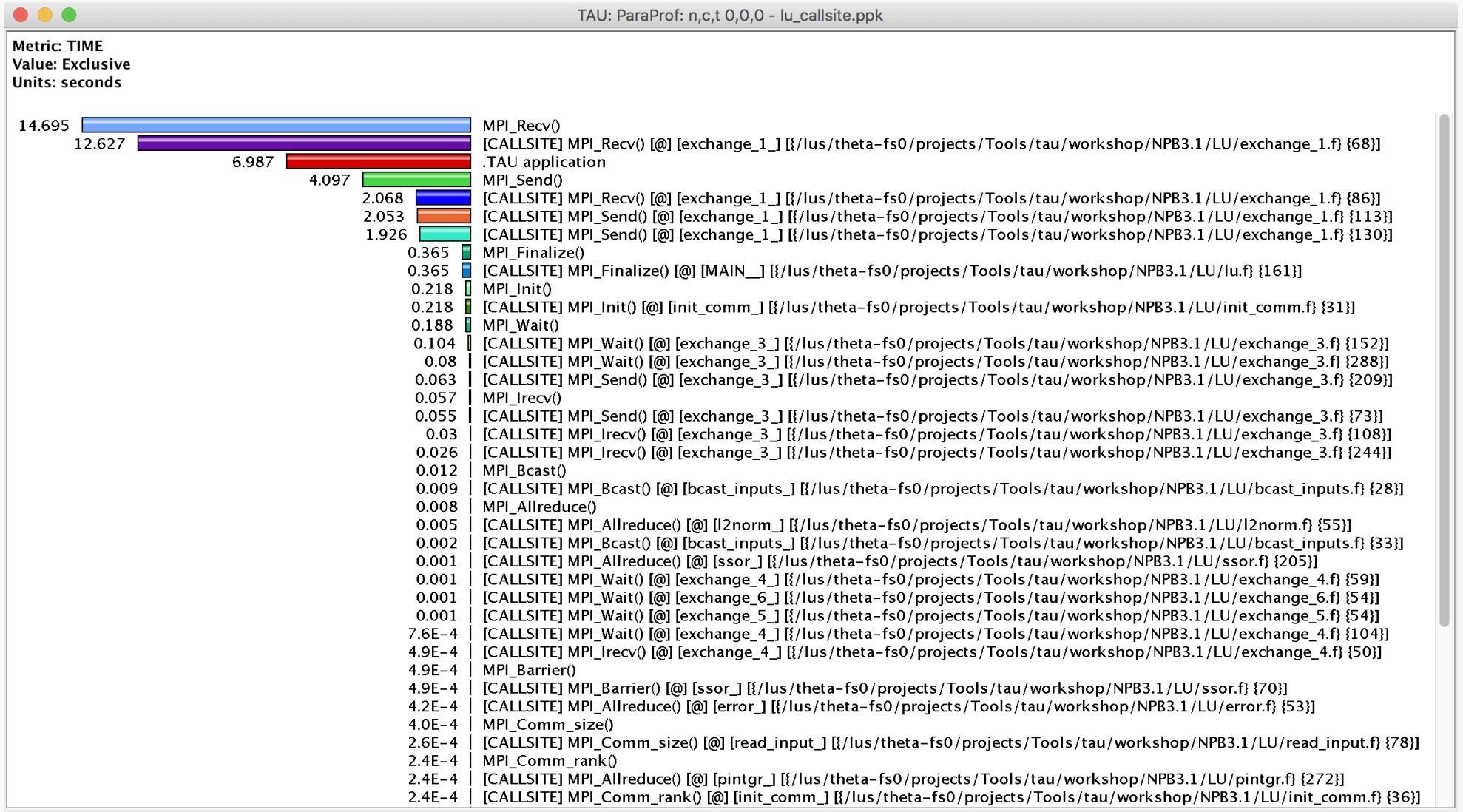
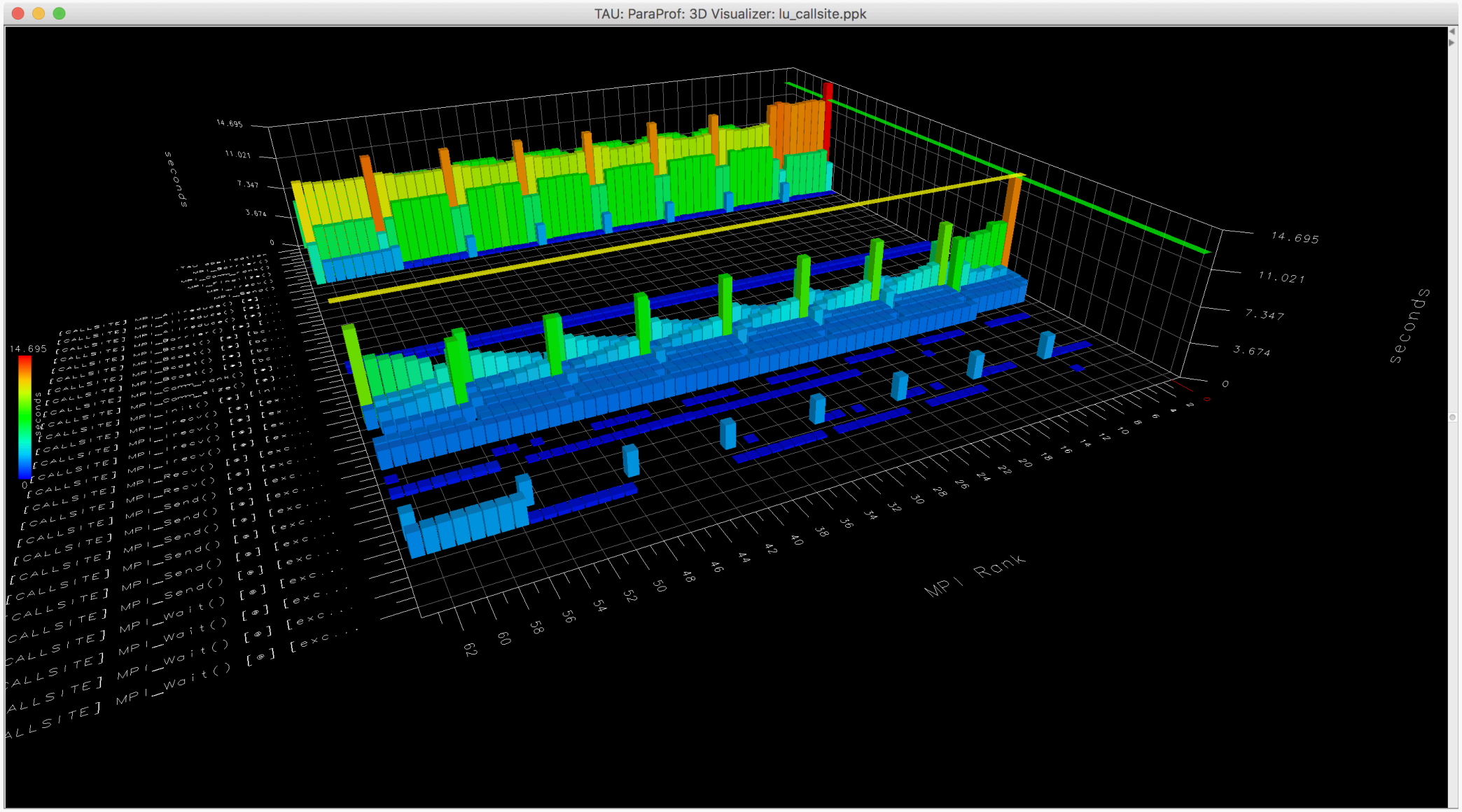
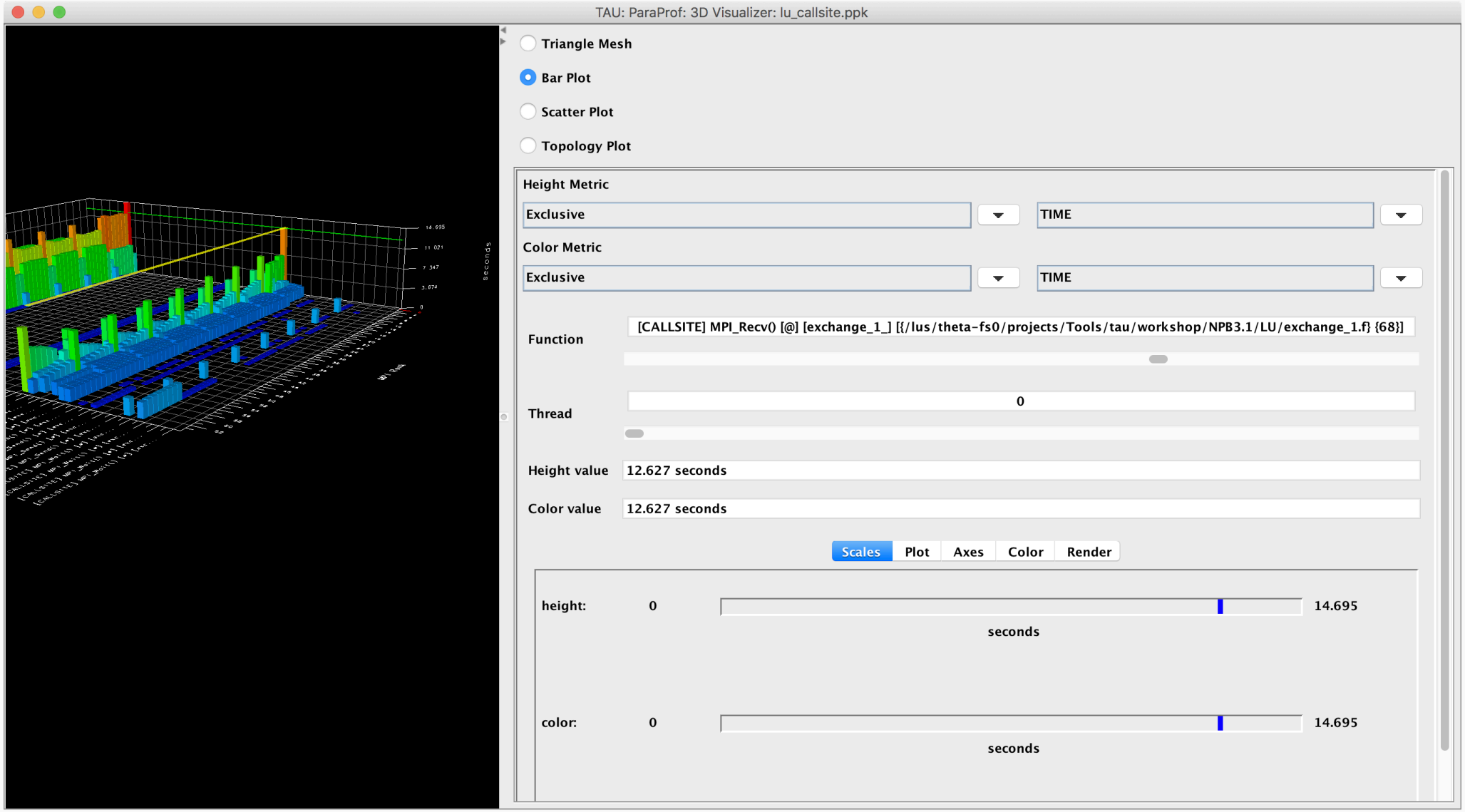
Callsite Profiling and Tracing (TAU_CALLSITE=1)



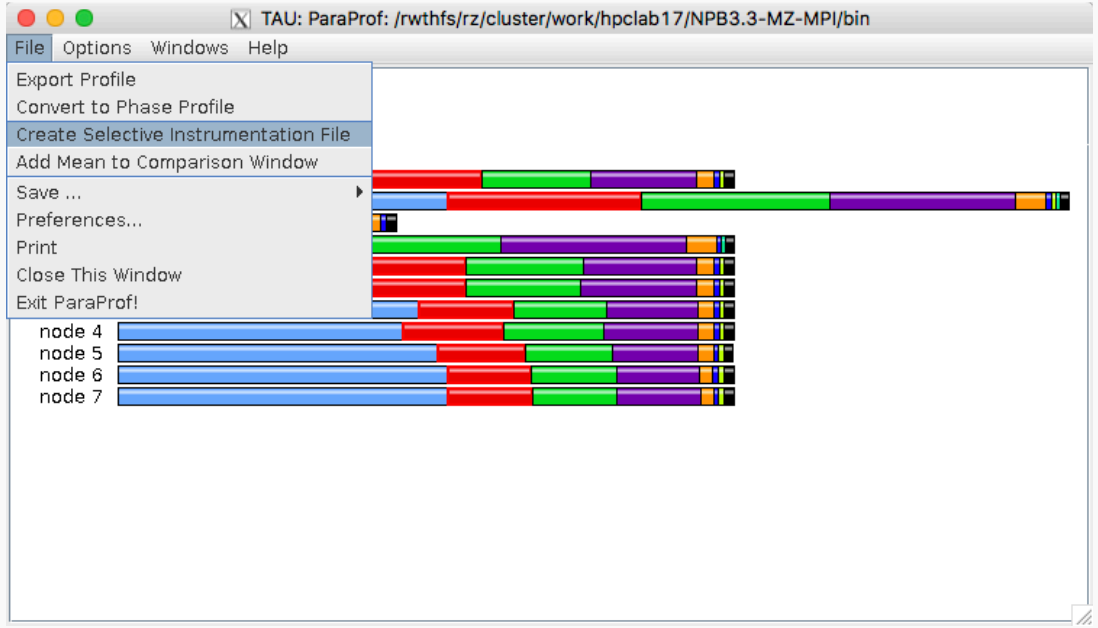
Callsite Profiling and Tracing

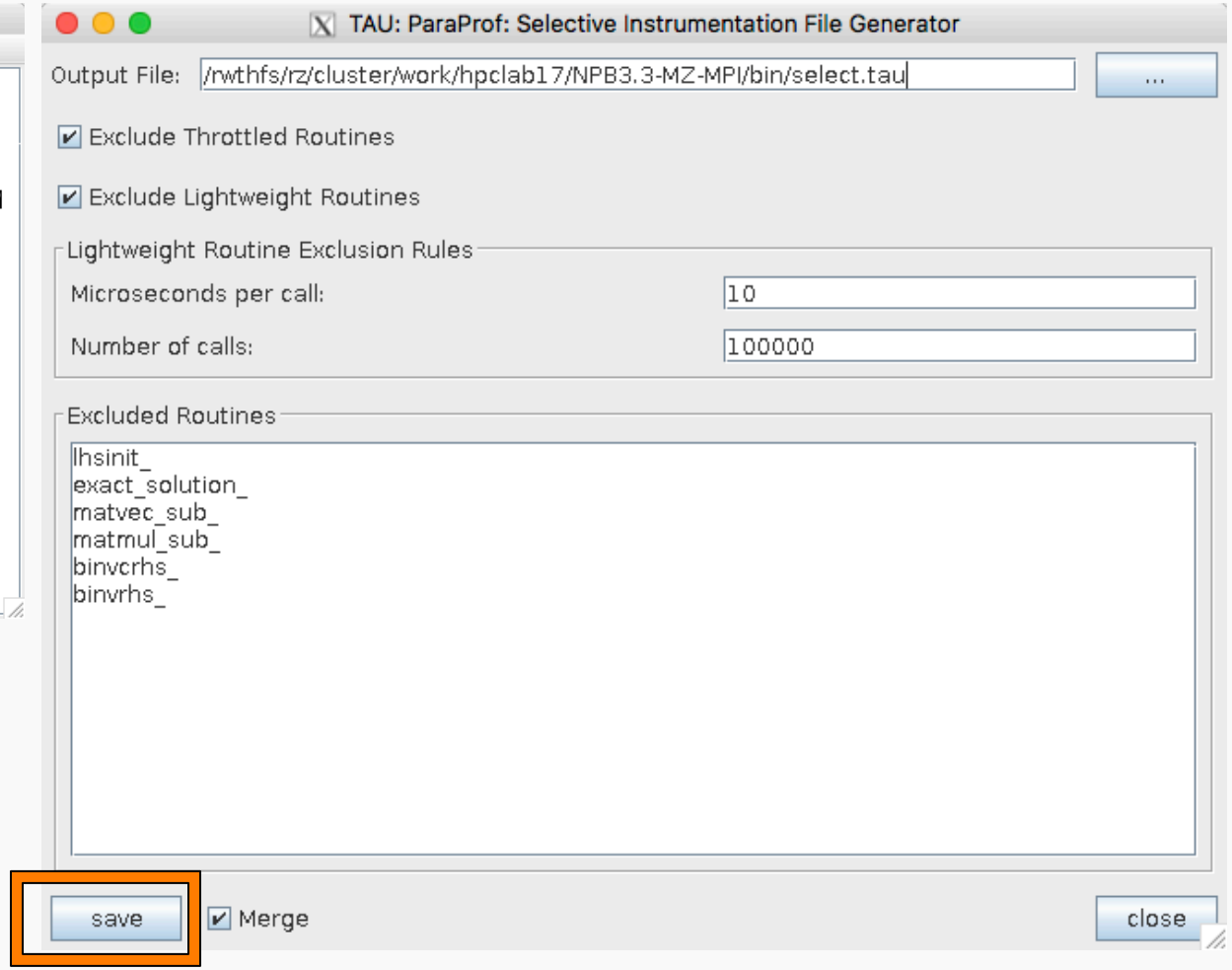


Callsite Profiling and Tracing

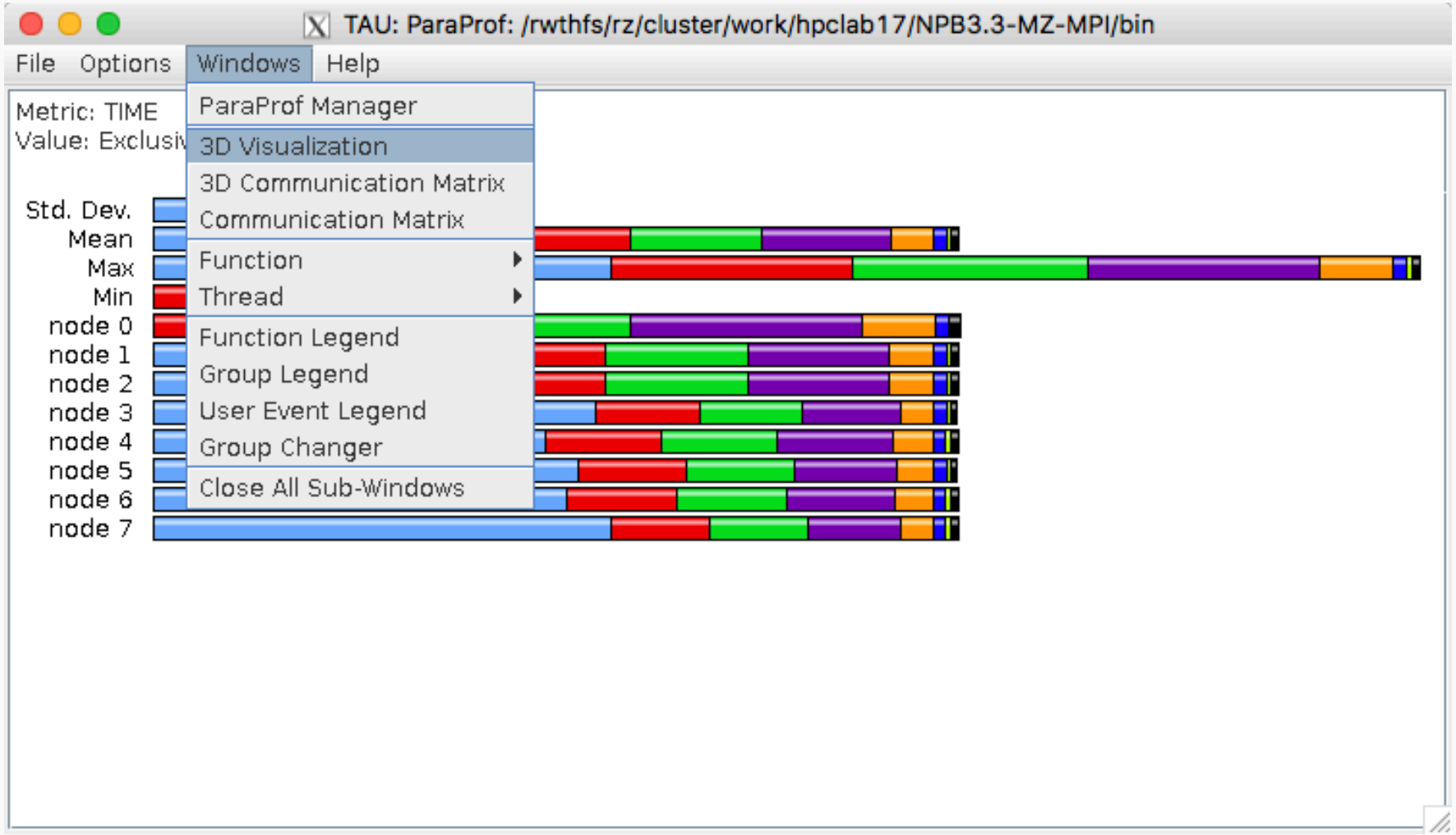


Create a Selective Instrumentation File, Re-instrument, Re-run

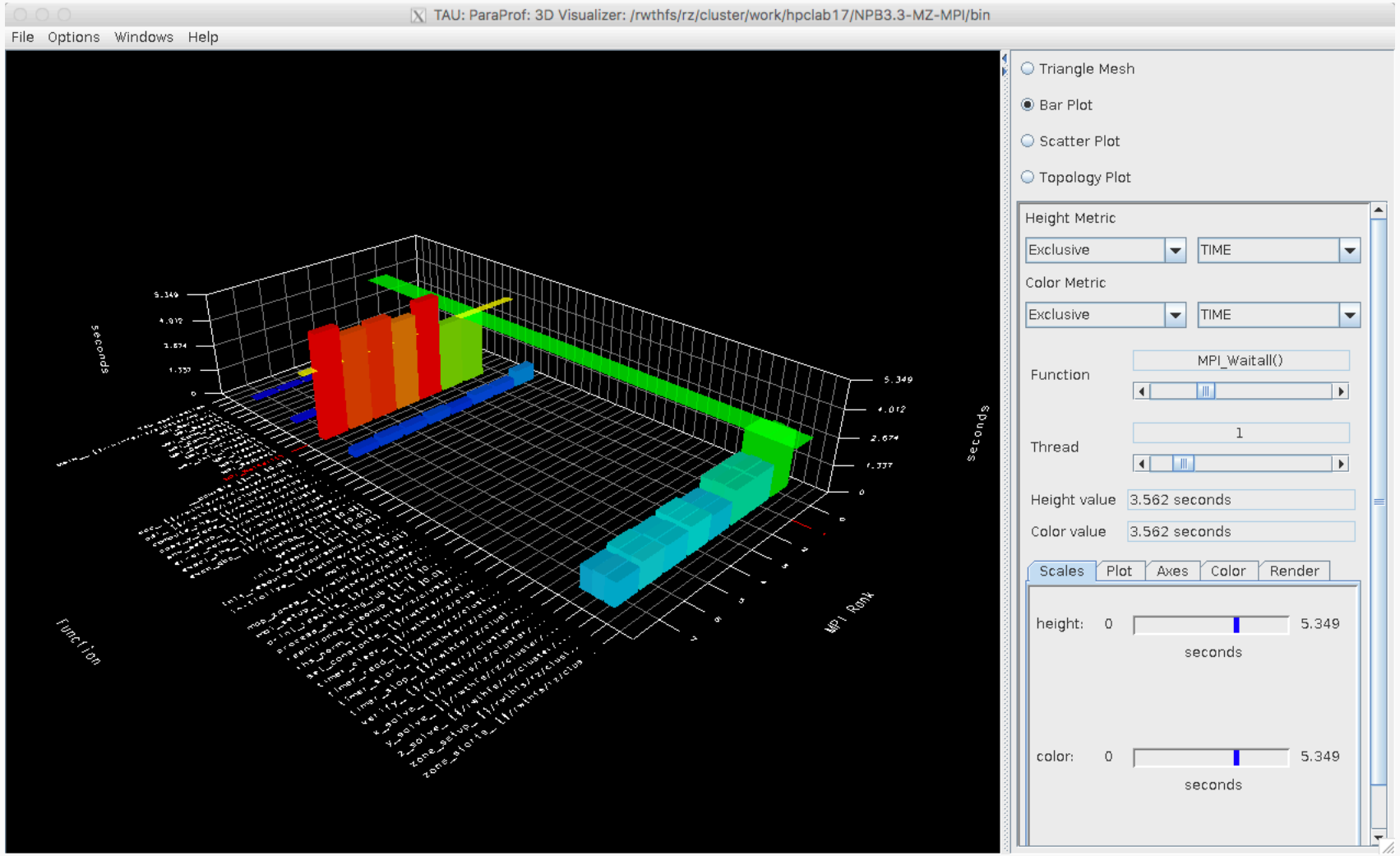




ParaProf with Optimized Instrumentation

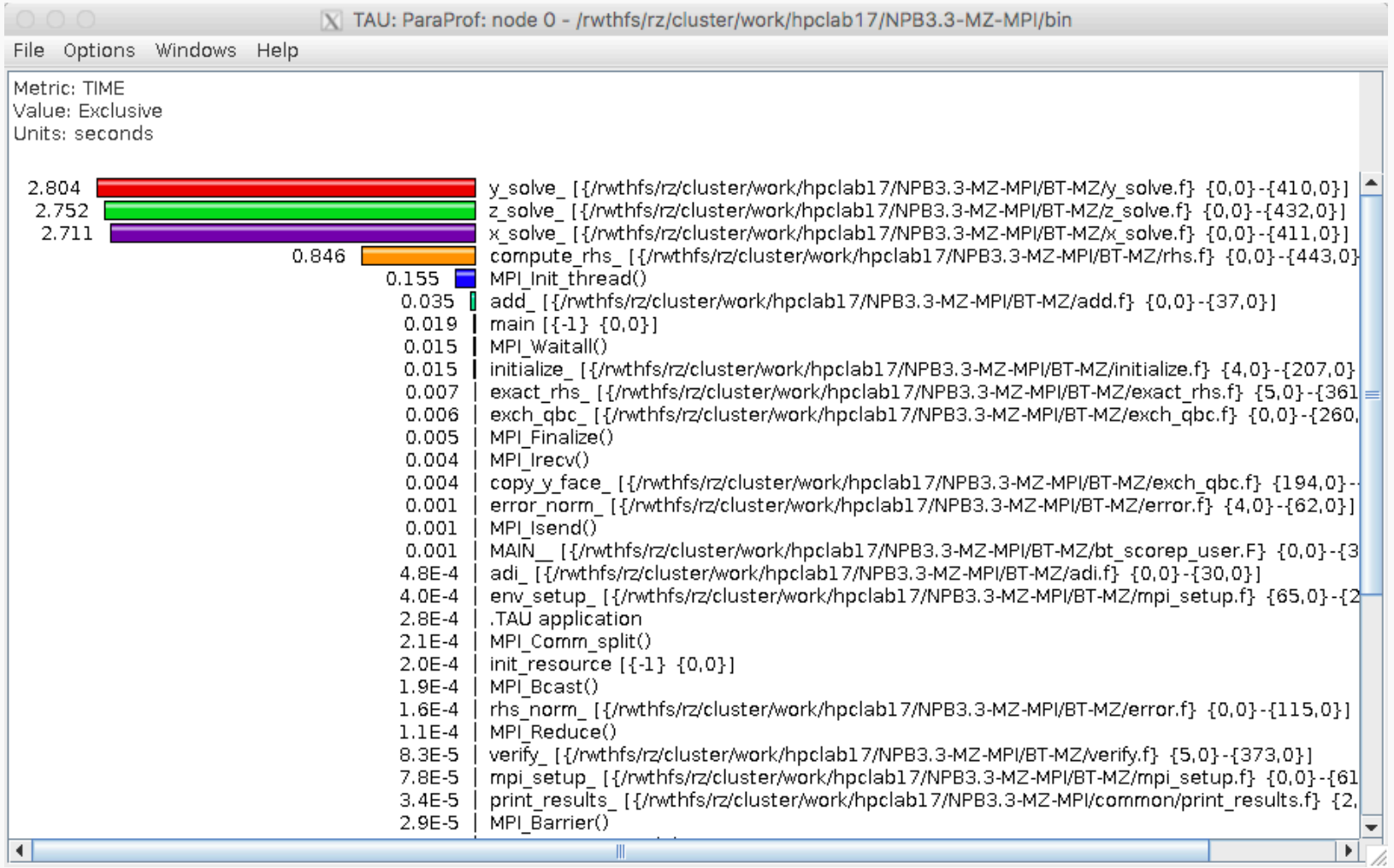


3D Visualization with ParaProf



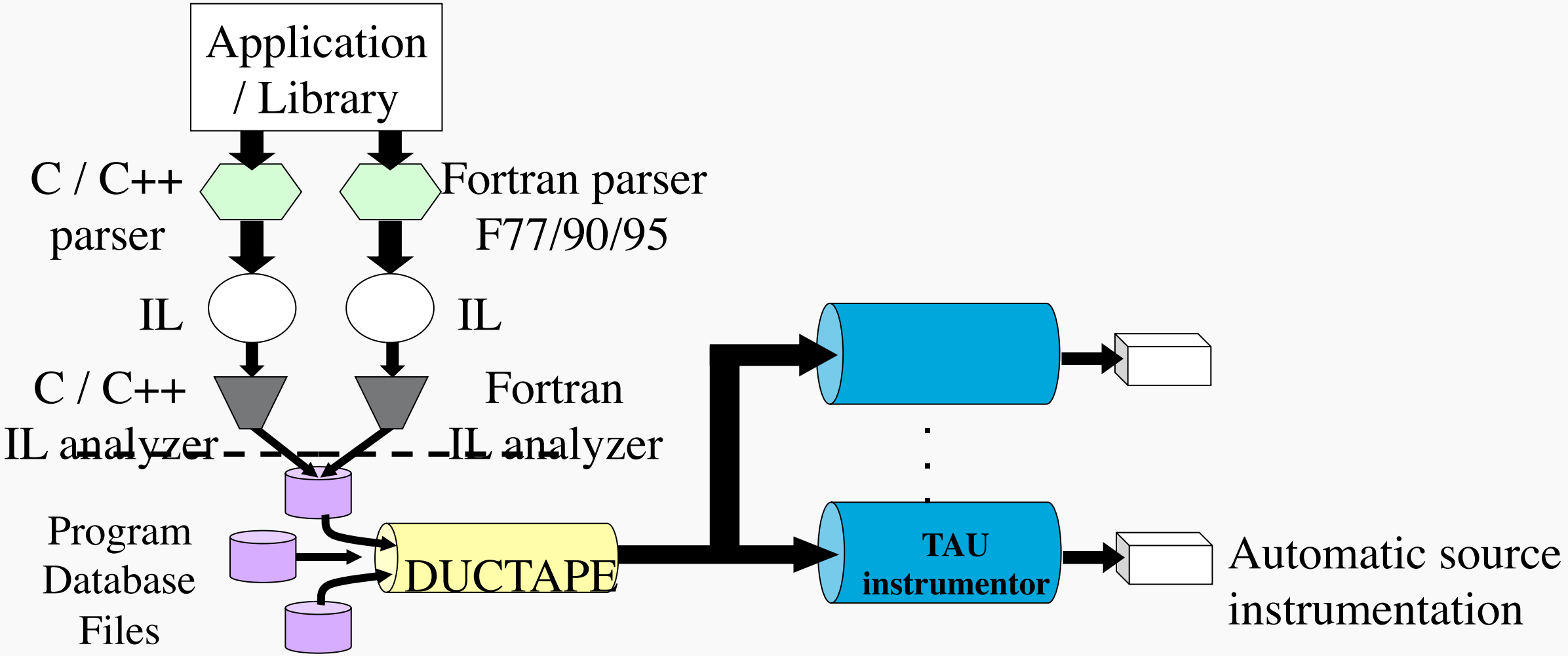
ParaProf: Node 0

Optimized instrumentation!

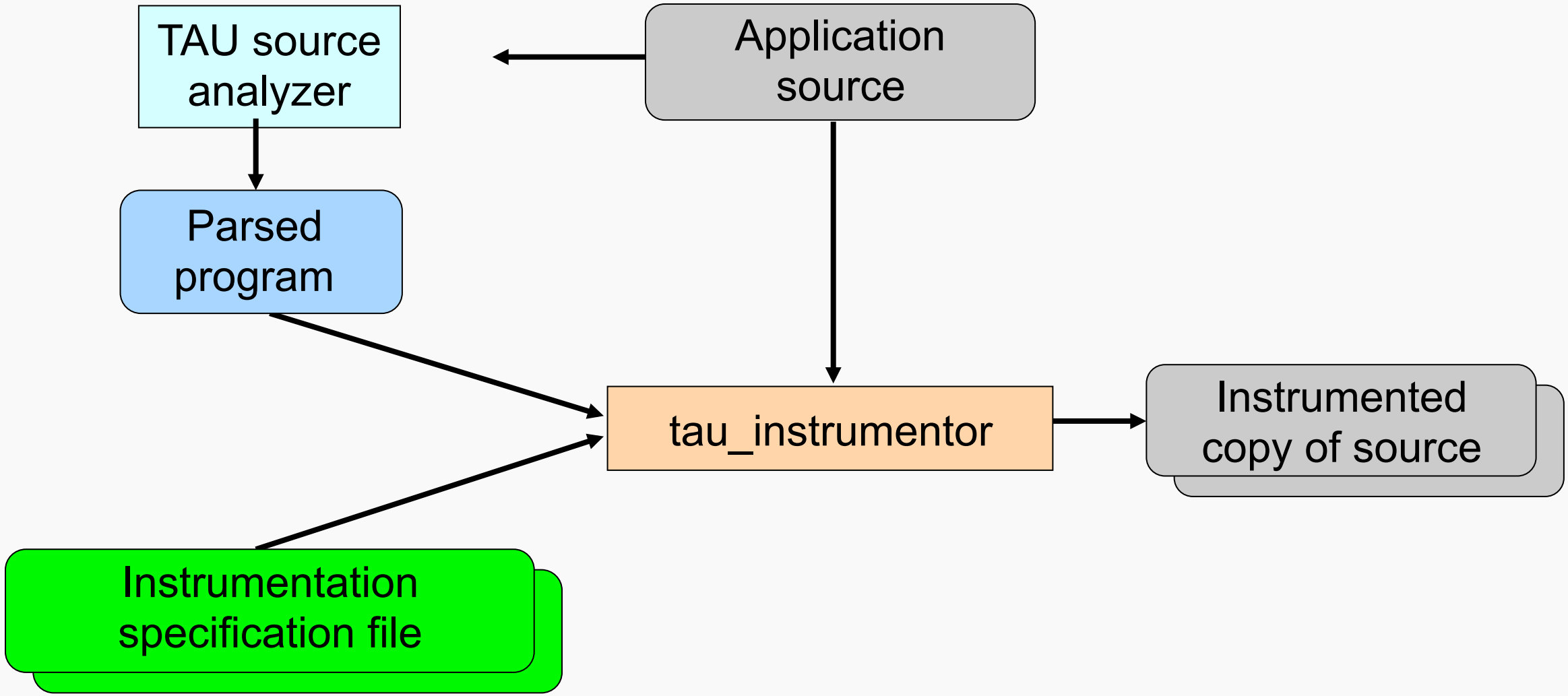


SOURCE INSTRUMENTATION

TAU's Static Analysis System: Program Database Toolkit (PDT)



PDT: automatic source instrumentation



Using SOURCE Instrumentation in TAU

TAU supports several compilers, measurement, and thread options

- Intel compilers, profiling with hardware counters using PAPI, MPI library, OpenMP…
- Each measurement configuration of TAU corresponds to a unique stub makefile (configuration file) and library that is generated when you configure it

To instrument source code automatically using PDT

- Choose an appropriate TAU stub makefile in <arch>/lib:

```
% module load UNITE tau

% export TAU_MAKEFILE=$TAU/Makefile.tau-intel-papi-mpi-pdt
% export TAU_OPTIONS= '-optVerbose …'  (see tau_compiler.sh )
```

- Use tau_f90.sh, tau_cxx.sh, tau_upc.sh, or tau_cc.sh as F90, C++, UPC, or C compilers respectively:

```
% ftn          foo.f90       changes to
% tau_f90.sh foo.f90
```

Set runtime environment variables, execute application and analyze performance data:

```
% pprof   (for text based profile display)
% paraprof  (for GUI)
```

Installing TAU

Installing PDT:

- wget http://tau.uoregon.edu/pdt_lite.tgz
- ./configure –prefix=<dir>; make ; make install

Installing TAU on Theta:

- wget http://tau.uoregon.edu/tau.tgz
- ./configure –arch=craycnl -mpi –pdt=<dir> -bfd=download –unwind=download –iowrapper;
- make install
- For x86_64 clusters running Linux
- ./configure -c++=mpicxx –cc=mpicc –fortran=mpif90 –pdt=<dir> -bfd=download –unwind=download
- make install

Using TAU:

- export TAU_MAKEFILE=<taudir>/x86_64/lib/Makefile.tau-<TAGS>
- make CC=tau_cc.sh CXX=tau_cxx.sh F90=tau_f90.sh

INSTALLING TAU on Laptops

Installing TAU under Mac OS X:

- wget http://tau.uoregon.edu/tau.dmg
- Install tau.dmg

Installing TAU under Windows

- http://tau.uoregon.edu/tau.exe

Installing TAU under Linux

- http://tau.uoregon.edu/tau.tgz
  - ./configure; make install
  - export PATH=<taudir>/x86_64/bin:$PATH

Different Makefiles for TAU Compiler

```
%  module load tau
% ls $TAU/Makefile.*
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-mpi-pdt
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-mpi-pdt
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-mpi-pdt-openmp-opari
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-mpi-pthread-pdt
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-ompt-mpi-pdt-openmp
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-ompt-pdt-openmp
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-pdt
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-pdt-openmp-opari
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-intel-papi-pthread-pdt
/soft/perftools/tau/tau-2.27/craycnl/lib/Makefile.tau-llvm-mpi-pdt
```

For an MPI+OpenMP+F90 application with Intel MPI, you may choose

Makefile.tau-intel-papi-ompt-mpi-pdt-openmp

– Supports MPI instrumentation & PDT for automatic source instrumentation

```
% export TAU_MAKEFILE=$TAU/Makefile.tau-intel-papi-ompt-mpi-pdt-openmp
% tau_f90.sh app.f90 -o app; aprun -n 256 ./app; paraprof
```

Configuration tags for tau_exec

```
% ./configure -pdt=<dir> -mpi -papi=<dir>; make install
```
Creates in $TAU:
```
Makefile.tau-papi-mpi-pdt(Configuration parameters in stub makefile)
shared-papi-mpi-pdt/libTAU.so

% ./configure -pdt=<dir> -mpi; make install
```
creates
```
Makefile.tau-mpi-pdt
shared-mpi-pdt/libTAU.so
```

To explicitly choose preloading of shared-<options>/libTAU.so change:
```
% aprun -n  256 ./a.out
```
to
```
% aprun -n  256  tau_exec -T <comma_separated_options> ./a.out

% aprun -n  256  tau_exec -T papi,mpi,pdt ./a.out
```
Preloads `$TAU/shared-papi-mpi-pdt/libTAU.so`
```
% aprun -n  256  tau_exec -T papi ./a.out
```
Preloads `$TAU/shared-papi-mpi-pdt/libTAU.so by matching.`
```
% aprun -n 256 tau_exec -T papi,mpi,pdt -s ./a.out
```
Does not execute the program. Just displays the library that it will preload if executed without the –s option.
NOTE: -mpi configuration is selected by default. Use –T serial for
Sequential programs.

Compile-Time Options

Optional parameters for the TAU_OPTIONS environment variable:
% tau_compiler.sh

-optVerbose	Turn on verbose debugging messages
-optCompInst	Use compiler based instrumentation
-optNoCompInst	Do not revert to compiler instrumentation if source instrumentation fails.
-optTrackIO	Wrap POSIX I/O call and calculates vol/bw of I/O operations (configure TAU with *–iowrapper*)
-optTrackGOMP	Enable tracking GNU OpenMP runtime layer (used without –opari)
-optMemDbg	Enable runtime bounds checking (see TAU_MEMDBG_* env vars)
-optKeepFiles	Does not remove intermediate .pdb and .inst.* files
-optPreProcess	Preprocess sources (OpenMP, Fortran) before instrumentation
-optTauSelectFile=”<file>"	Specify selective instrumentation file for *tau_instrumentor*
-optTauWrapFile=”<file>"	Specify path to *link_options.tau* generated by *tau_gen_wrapper*
-optHeaderInst	Enable Instrumentation of headers
-optTrackUPCR	Track UPC runtime layer routines (used with tau_upc.sh)
-optLinking=""	Options passed to the linker. Typically $(TAU_MPI_FLIBS) $(TAU_LIBS) $(TAU_CXXLIBS)
-optCompile=""	Options passed to the compiler. Typically $(TAU_MPI_INCLUDE) $(TAU_INCLUDE) $(TAU_DEFS)
-optPdtF95Opts=""	Add options for Fortran parser in PDT (f95parse/gfparse) …

Compile-Time Options (contd.)

Optional parameters for the TAU_OPTIONS environment variable:
% tau_compiler.sh

-optMICOffload	Links code for Intel MIC offloading, requires both host and MIC TAU libraries
-optShared	Use TAU's shared library (libTAU.so) instead of static library (default)
-optPdtCxxOpts=""	Options for C++ parser in PDT (cxxparse).
-optPdtF90Parser=""	Specify a different Fortran parser
-optPdtCleanscapeParser	Specify the Cleanscape Fortran parser instead of GNU gfparser
-optTau=""	Specify options to the tau_instrumentor
-optTrackDMAPP	Enable instrumentation of low-level DMAPP API calls on Cray
-optTrackPthread	Enable instrumentation of pthread calls

See tau_compiler.sh for a full list of TAU_OPTIONS.

…

Compiling Fortran Codes with TAU

If your Fortran code uses free format in .f files (fixed is default for .f), you may use:

```
% export TAU_OPTIONS= '-optPdtF95Opts="-R free" -optVerbose '
```

To use the compiler based instrumentation instead of PDT (source-based):

```
% export TAU_OPTIONS= '-optCompInst -optVerbose'
```

If your Fortran code uses C preprocessor directives (#include, #ifdef, #endif):

```
% export TAU_OPTIONS= '-optPreProcess -optVerbose -optDetectMemoryLeaks'
```

To use an instrumentation specification file:

```
% export TAU_OPTIONS= '-optTauSelectFile=select.tau -optVerbose -optPreProcess'
% cat select.tau
BEGIN_INSTRUMENT_SECTION
loops  routine="#"
# this statement instruments all outer loops in all routines. # is wildcard as well as comment in first column.
END_INSTRUMENT_SECTION
```

Selective Instrumentation File Format

To use an instrumentation specification file for source instrumentation:

% export TAU_OPTIONS= '-optTauSelectFile=/path/to/select.tau –optVerbose '

% cat select.tau

```
BEGIN_EXCLUDE_LIST
BINVCRHS
MATMUL_SUB
MATVEC_SUB
EXACT_SOLUTION
BINVRHS
LHS#INIT
TIMER_#
END_EXCLUDE_LIST
```

NOTE: paraprof can create this file from an earlier execugtion for you.

File -> Create Selective Instrumentation File -> save

Selective instrumentation at runtime:

% export TAU_SELECT_FILE=select.tau

TAU COMMANDER

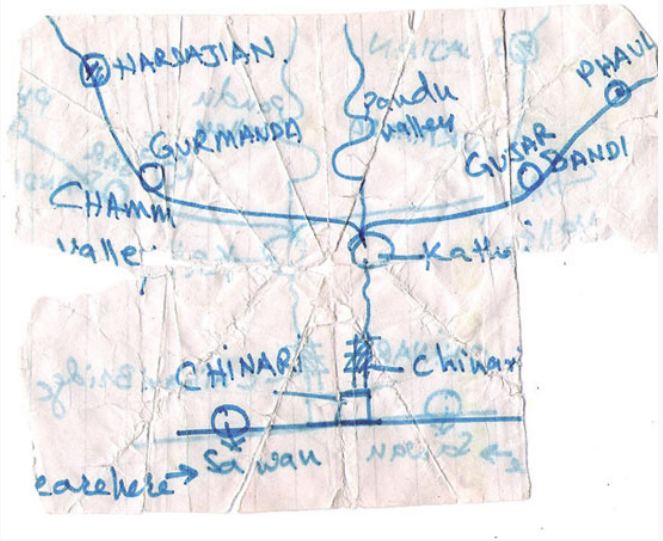
Argonne NATIONAL LABORATORY

TAU Commander's Approach

Say where you're going, not how to get there

Experiments give **context** to the user's actions

- Defines desired metrics and measurement approach
- Defines operating environment
- Establishes a baseline for error checking



VS.

Getting Started with TAU Commander

1. **tau** initialize
2. **tau** ftn*.f90 -o foo
3. **tau** aprun -n 64 ./foo
4. **tau** show
5. **tau** --help
6. **tau** show --help

- This works on any supported system, even if TAU is not installed or has not been configured appropriately.
- TAU and all its dependencies will be downloaded and installed if required.

- https://github.com/ParaToolsInc/taucmdr

TAU Commander online help

jlinford — ssh cori.nersc.gov — 80×47

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau --help
usage: tau [arguments] <subcommand> [options]

TAU Commander 1.0a [ www.taucommander.com ]

Positional Arguments:
  <subcommand>   See subcommand descriptions below.
  [options]      Options to be passed to <subcommand>.

Optional Arguments:
  -V, --version  Show program's version number and exit.
  -h, --help     Show this help message and exit.
  -q, --quiet    Suppress all output except error messages.
  -v, --verbose  Show debugging messages.

Configuration Subcommands:
  application     Create and manage application configurations.
  experiment      Create and manage experiments.
  measurement     Create and manage measurement configurations.
  project         Create and manage project configurations.
  target          Create and manage target configurations.
  trial           Create and manage experiment trials.

Subcommands:
  build           Instrument programs during compilation and/or linking.
  configure       Configure TAU Commander.
  dashboard       Show all project components.
  help            Show help for a command or suggest actions for a file.
  initialize      Initialize TAU Commander.
  select          Create a new experiment or select an existing experiment.

Shortcuts:
  tau <compiler>  Execute a compiler command
                  - Example: tau gcc *.c -o a.out
                  - Alias for 'tau build <compiler>'
  tau <program>   Gather data from a program
                  - Example: tau ./a.out
                  - Alias for 'tau trial create <program>'
  tau metrics     Show metrics available in the current experiment
                  - Alias for 'tau target metrics'
  tau select      Select configuration objects to create a new experiment
                  - Alias for 'tau experiment create'
  tau show        Show data from the most recent trial
                  - Alias for 'tau trial show'

See 'tau help <subcommand>' for more information on <subcommand>.
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $
```

jlinford — ssh cori.nersc.gov — 80×35

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau app cre --help
usage: tau application create <application_name> [arguments]

Create application configurations.

Optional Arguments:
  -@ <level>            Create the application at the specified storage
                        level.
                          - <level>: project, user, system
                          - default: project
  -h, --help            Show this help message and exit.

Application Arguments:
  <application_name>    Application configuration name.
  --cuda [T/F]          Application uses NVIDIA CUDA.
                          - default: False
  --linkage <linkage>   Application linkage.
                          - <linkage>: static, dynamic
                          - default: static
  --mpc [T/F]           Application uses MPC.
                          - default: False
  --mpi [T/F]           Application uses MPI.
                          - default: False
  --opencl [T/F]        Application uses OpenCL.
                          - default: False
  --openmp [T/F]        Application uses OpenMP.
                          - default: False
  --pthreads [T/F]      Application uses pthreads.
                          - default: False
  --select-file path    Specify selective instrumentation file.
  --shmem [T/F]         Application uses SHMEM.
                          - default: False
  --tbb [T/F]           Application uses Thread Building Blocks (TBB).
                          - default: False
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $
```

Runtime Environment Variables

Environment Variable	Default	Description
TAU_TRACE	0	Setting to 1 turns on tracing
TAU_CALLPATH	0	Setting to 1 turns on callpath profiling
TAU_TRACK_MEMORY_FOOTPRINT	0	Setting to 1 turns on tracking memory usage by sampling periodically the resident set size and high water mark of memory usage
TAU_TRACK_POWER	0	Tracks power usage by sampling periodically.
TAU_CALLPATH_DEPTH	2	Specifies depth of callpath. Setting to 0 generates no callpath or routine information, setting to 1 generates flat profile and context events have just parent information (e.g., Heap Entry: foo)
TAU_SAMPLING	1	Setting to 1 enables event-based sampling.
TAU_TRACK_SIGNALS	0	Setting to 1 generate debugging callstack info when a program crashes
TAU_COMM_MATRIX	0	Setting to 1 generates communication matrix display using context events
TAU_THROTTLE	1	Setting to 0 turns off throttling. Throttles instrumentation in lightweight routines that are called frequently
TAU_THROTTLE_NUMCALLS	100000	Specifies the number of calls before testing for throttling
TAU_THROTTLE_PERCALL	10	Specifies value in microseconds. Throttle a routine if it is called over 100000 times and takes less than 10 usec of inclusive time per call
TAU_CALLSITE	0	Setting to 1 enables callsite profiling that shows where an instrumented function was called. Also compatible with tracing.
TAU_PROFILE_FORMAT	Profile	Setting to “merged” generates a single file. “snapshot” generates xml format
TAU_METRICS	TIME	Setting to a comma separated list generates other metrics. (e.g., ENERGY,TIME,P_VIRTUAL_TIME,PAPI_FP_INS,PAPI_NATIVE_<event>:<subevent>)

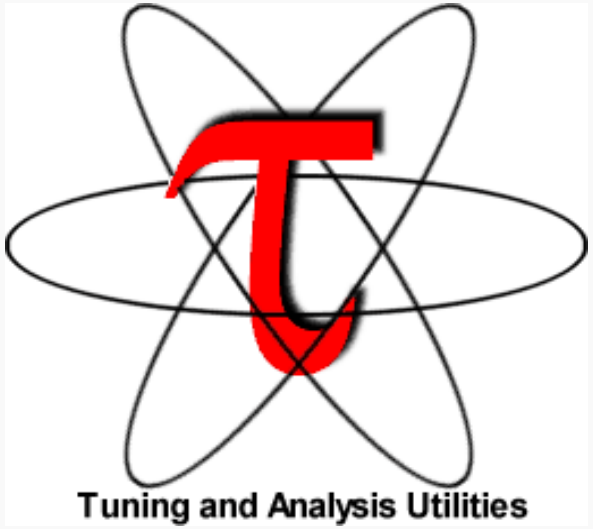
Runtime Environment Variables

Environment Variable	Default	Description
TAU_TRACE	0	Setting to 1 turns on tracing
TAU_TRACE_FORMAT	Default	Setting to “otf2” turns on TAU’s native OTF2 trace generation (configure with –otf=download)
TAU_EBS_UNWIND	0	Setting to 1 turns on unwinding the callstack during sampling (use with tau_exec –ebs or TAU_SAMPLING=1)
TAU_TRACK_LOAD	0	Setting to 1 tracks system load on the node
TAU_SELECT_FILE	Default	Setting to a file name, enables selective instrumentation based on exclude/include lists specified in the file.
TAU_OMPT_SUPPORT_LEVEL	basic	Setting to “full” improves resolution of OMPT TR6 regions on threads 1.. N-1. Also, “lowoverhead” option is available.
TAU_OMPT_RESOLVE_ADDRESS_EAGERLY	0	Setting to 1 is necessary for event based sampling to resolve addresses with OMPT TR6 (-ompt=download-tr6)

Runtime Environment Variables (contd.)

Environment Variable	Default	Description
TAU_TRACK_MEMORY_LEAKS	0	Tracks allocates that were not de-allocated (needs –optMemDbg or tau_exec –memory)
TAU_EBS_SOURCE	TIME	Allows using PAPI hardware counters for periodic interrupts for EBS (e.g., TAU_EBS_SOURCE=PAPI_TOT_INS when TAU_SAMPLING=1)
TAU_EBS_PERIOD	100000	Specifies the overflow count for interrupts
TAU_MEMDBG_ALLOC_MIN/MAX	0	Byte size minimum and maximum subject to bounds checking (used with TAU_MEMDBG_PROTECT_*)
TAU_MEMDBG_OVERHEAD	0	Specifies the number of bytes for TAU's memory overhead for memory debugging.
TAU_MEMDBG_PROTECT_BELOW/ABOVE	0	Setting to 1 enables tracking runtime bounds checking below or above the array bounds (requires –optMemDbg while building or tau_exec –memory)
TAU_MEMDBG_ZERO_MALLOC	0	Setting to 1 enables tracking zero byte allocations as invalid memory allocations.
TAU_MEMDBG_PROTECT_FREE	0	Setting to 1 detects invalid accesses to deallocated memory that should not be referenced until it is reallocated (requires –optMemDbg or tau_exec –memory)
TAU_MEMDBG_ATTEMPT_CONTINUE	0	Setting to 1 allows TAU to record and continue execution when a memory error occurs at runtime.
TAU_MEMDBG_FILL_GAP	Undefined	Initial value for gap bytes
TAU_MEMDBG_ALINGMENT	Sizeof(int)	Byte alignment for memory allocations
TAU_EVENT_THRESHOLD	0.5	Define a threshold value (e.g., .25 is 25%) to trigger marker events for min/max

Download TAU from U. Oregon



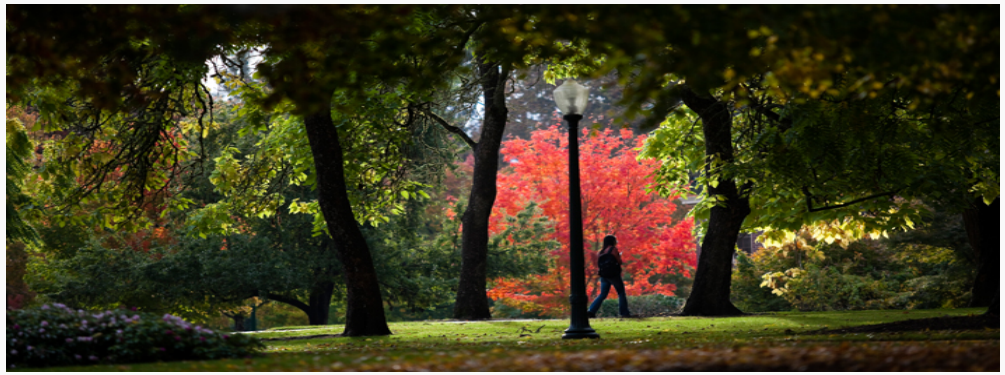
http://www.hpclinux.com [OVA file]

http://tau.uoregon.edu

for more information

Free download, open source, BSD license

PRL, University of Oregon, Eugene



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- PETTT, HPCMP

National Science Foundation (NSF)
- SI2-SSI, Glassbox

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- The Ohio State University
- ParaTools, Inc.
- University of Tennessee, Knoxville
- T.U. Dresden, GWT
- Jülich Supercomputing Center


THANK YOU! QUESTIONS?