

## **TAU Performance System®**



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# Wouldn't it be nice if we could ...

- Instrument and measure performance of MPI and CUDA/ROCm/SYCL/OpenMP applications with:
  - No change to the source code
  - No change to the build system
  - No change to the application binary!

And use some of the tools we are already familiar with like Score-P, Scalasca, CUBE, Vampir, PAPI, Perfetto.dev...

A unifying framework: TAU

# **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? Using Likwid or PAPI, TAU measures floating point, Level 1 and 2 *data cache misses*, hits, branches taken.
- What is the time taken in OS routines for thread scheduling? How much time is wasted?
- 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?
- 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?

# **TAU Performance System®**

- Simple tool
  - No change to the application source code
  - No change to its build system
  - No change to its executable
  - Simply launch the application binary with tau\_exec
- Works with Score-P, OTF2/Vampir
- paraprof and perfexplorer: GUI tools
- pprof: text based browser
- Open Source: BSD style license

# **TAU: Quickstart Guide**

**Profiling:** 

MPI: % mpirun -np 16 tau exec -ebs ./a.out

- Pthread: % mpirun -np 16 tau\_exec -T mpi,pthread -ebs ./a.out
- CUDA: % mpirun -np 16 tau\_exec -T cupti,mpi -cupti -ebs ./a.out
- Score-P: % mpirun -np 16 tau\_exec -T scorep,mpi ./a.out

Analysis: % pprof -a -m | more; % paraprof (GUI)

Tracing:

- Vampir: MPI: % export TAU\_TRACE=1; export TAU\_TRACE\_FORMAT=otf2
   % mpirun -np 16 tau exec ./a.out; vampir traces.otf2 &
- Chrome/Jumpshot: % export TAU\_TRACE=1; mpirun -np 64 tau\_exec ./a.out
   % tau\_treemerge.pl;

Chrome: % tau\_trace2json tau.trc tau.edf -chrome -ignoreatomic -o app.json Chrome browser: chrome://tracing (Load -> app.json) or Perfetto.dev

• Jumpshot: tau2slog2 tau.trc tau.edf -o app.slog2; jumpshot app.slog2

# **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
  - Automatic instrumentation
- Measurement and analysis support
  - MPI, OpenSHMEM, ARMCI, PGAS, DMAPP
  - pthreads, OpenMP, OMPT interface, hybrid, other thread models
  - GPU, CUDA, OpenCL, OpenACC, ROCm, HIP
  - Parallel profiling and tracing
  - Use of Score-P for native OTF2 and CUBEX generation
  - Efficient callpath profiles and trace generation using Score-P
- Analysis
  - Parallel profile analysis (ParaProf), data mining (PerfExplorer)
  - Performance database technology (TAUdb)
  - 3D profile browser



# **TAU's Support for Runtime Systems**

#### • MPI

- PMPI profiling interface
- MPI\_T tools interface using performance and control variables
- Pthread
  - Captures time spent in routines per thread of execution

#### OpenMP

- OMPT tools interface to track salient OpenMP runtime events
- Opari source rewriter
- Preloading wrapper OpenMP runtime library when OMPT is not supported

## OpenACC

- OpenACC instrumentation API
- Track data transfers between host and device (per-variable)
- Track time spent in kernels

# TAU's Support for Runtime Systems (contd.)

#### OpenCL

- OpenCL profiling interface
- Track timings of kernels
- Intel<sup>®</sup> OneAPI
  - Level Zero
  - Track time spent in kernels executing on GPU
  - Track time spent in OneAPI runtime calls
- CUDA
  - Cuda Profiling Tools Interface (CUPTI)
  - Track data transfers between host and GPU
  - Track access to uniform shared memory between host and GPU
- ROCm
  - Rocprofiler and Roctracer instrumentation interfaces
  - Track data transfers and kernel execution between host and GPU
- Kokkos
  - Kokkos profiling API
  - Push/pop interface for region, kernel execution interface
- Python
  - Python interpreter instrumentation API
  - Tracks Python routine transitions as well as Python to C transitions



# **Examples of Multi-Level Instrumentation**

- MPI + OpenMP
  - MPI\_T + PMPI + OMPT may be used to track MPI and OpenMP
- MPI + CUDA
  - PMPI + CUPTI interfaces
- Kokkos + OpenMP
  - Kokkos profiling API + OMPT to transparently track events
- Kokkos + pthread + MPI
  - Kokkos + pthread wrapper interposition library + PMPI layer
- Python + CUDA + MPI
  - Python + CUPTI + pthread profiling interfaces (e.g., Tensorflow, PyTorch) + MPI
- MPI + OpenCL
  - PMPI + OpenCL profiling interfaces

#### **Performance Data Measurement**



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



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



# **Types of Performance Profiles**

#### Flat profiles

- Metric (e.g., time) spent in an event
- Exclusive/inclusive, # of calls, child calls, ...
- Callpath profiles
  - Time spent along a calling path (edges in callgraph)
  - "main=> f1 => f2 => MPI\_Send"
  - Set the TAU\_CALLPATH and TAU\_CALLPATH\_DEPTH environment variables
- Callsite profiles
  - Time spent along in an event at a given source location
  - Set the TAU\_CALLSITE environment variable
- Phase profiles
  - Flat profiles under a phase (nested phases allowed)
  - Default "main" phase
  - Supports static or dynamic (e.g. per-iteration) phases

# 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)
- Add tau\_exec before the name of the binary
  - ■mpirun –np 64 tau\_exec ./a.out
  - mpirun tau\_exec –T ompt,mpi,papi -ompt ./a.out

# VI-HPS

#### tau\_exec

\$ tau_e	xec		
Usage:	tau_exec [opti	Tau_exec preloads	
Options	<pre>-v -s -qsub -io -memory_debug -cuda -cupti -opencl -openacc -ompt -armci -ebs -ebs_period=&lt; -um -T <disable.g< pre=""></disable.g<></pre>	<pre>Verbose mode Show what will be done but don't actually do anything (dryrun) Use qsub mode (BG/P only, see below) Track I/O Track memory allocation/deallocation Enable memory debugger Track GPU events via CUDA Track GPU events via CUPTI (Also see env. variable TAU_CUPTI_API) Track GPU events via OpenCL Track GPU events via OpenACC (currently PGI only) Track OpenMP events via OMPT interface Track ARMCI events via PARMCI Enable event-based sampling count&gt; Sampling period (default 1000) counter&gt; Counter (default itimer) Enable Unified Memory events via CUPTI NU.ICPC.MET.OPENMP.PAPI.PDT.PROFILE.PTHREAD.SCOREP.SERIAL&gt; : Specify TAU tag</pre>	the TAU wrapper libraries and performs measurements.
	-loadlib= <fil< td=""><td>e.so&gt; : Specify additional load library</td><td>5</td></fil<>	e.so> : Specify additional load library	5
	-XrunTAUsh- <o< td=""><td>ptions&gt; : Specify TAU library directly</td><td></td></o<>	ptions> : Specify TAU library directly	
Notes:	-gdb	Run program in the gdb debugger No need to	recompile the application!
	Defaults i MPI is ass	I UNSPECIFIED: -T MPI	

# tau\_exec Example (continued)

```
Example:
    mpirun -np 2 tau exec -T icpc,ompt,mpi -ompt ./a.out
    mpirun -np 2 tau exec -io ./a.out
Example - event-based sampling with samples taken every 1,000,000 FP instructions
    mpirun -np 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:
      gsub -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 the -ebs flag!

# Simplifying TAU's usage (tau\_exec)

- •Uninstrumented execution linked with –dynamic (dynamic executables only!)
- % mpirun -np 16 ./a.out
- Track MPI performance
  - % mpirun -np 16 tau\_exec ./a.out
- Track OpenMP, and MPI performance (MPI enabled by default; OMPT in Clang 9+, Intel 19+) % export TAU\_OMPT\_SUPPORT\_LEVEL=full;
  - % mpirun -np 16 tau\_exec -T mpi,pdt,ompt,papi -ompt ./a.out
- Track memory operations
  - % export TAU\_TRACK\_MEMORY\_LEAKS=1
  - % mpirun -np 16 tau\_exec -memory\_debug ./a.out (bounds check)
- ■Use event based sampling (compile with –g)
  - % mpirun -np 16 tau\_exec -ebs ./a.out
- Also \_ebs\_source=<PAPI\_COUNTER> -ebs\_period=<overflow\_count> -ebs\_resolution=<file|function|line>
- Load wrapper interposition library
  - % mpirun -np 16 tau\_exec -loadlib=<path/libwrapper.so> ./a.out
- Track GPGPU operations (-rocm, -I0, -opencl, -cupti, -cupti –um, -openacc):
  - % mpirun -np 16 tau\_exec -cupti ./a.out

# **Installing and Configuring TAU**

# Installing PDT:

- wget http://tau.uoregon.edu/pdt.tgz
- ./configure; make ; make install

# Installing TAU :

- wget http://tau.uoregon.edu/tau.tgz
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- make install; export PATH=<taudir>/arm64\_linux/bin:\$PATH
- All configurations are stored in <taudir>/.all\_configs if you wish to see how TAU was configured!
- •Using TAU for source instrumentation:
  - export TAU\_MAKEFILE=<taudir>/x86\_64/lib/Makefile.tau-<TAGS>
  - make CC=tau\_cc.sh CXX=tau\_cxx.sh F90=tau\_f90.sh
  - Use tau\_exec with uninstrumented binaries instead of recompiling the source code.

# **Configurations available on CoolMuc2, LRZ**

- % module use /lrz/sys/courses/vihps/2024/modulefiles/
- % module load tau
- % ls \$TAU/Makefile\*

```
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-intel-papi-mpi-pdt-scorep
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-intel-papi-mpi-pthread-pdt
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-intel-papi-ompt-mpi-pdt-openmp
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-papi-mpi-pdt
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-papi-pdt
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-papi-pthread-pdt
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-papi-tbb-pdt
For an uninstrumented binary:
% mpirun -np 16 tau exec -T mpi,scorep ./a.out
Picks the configuration represented by
/lrz/sys/courses/vihps/2024/tools/tau/tau-2.33.2/x86 64/lib/Makefile.tau-intel-papi-mpi-pdt-scorep
To use OpenMP instrumentation:
% export TAU OMPT SUPPORT LEVEL=full
% export OMP NUM THREADS=<N>
% mpirun -np 16 tau_exec -T ompt,mpi -ompt -ebs ./a.out
% pprof -a
            more
% paraprof
% paraprof --pack foo.ppk
# Copy it to your local machine and launch: % paraprof foo.ppk
```

#### **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:
% mpirun -np 256 ./a.out
                             to
% mpirun -np 256 tau exec -T < comma separated options> ./a.out
% mpirun -np 256 tau exec -T papi,mpi,pdt ./a.out
Preloads $TAU/shared-papi-mpi-pdt/libTAU.so
% mpirun -np 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.
```

# **Binary instrumentation of libraries: Work in progress**

- \* tau\_run a.out -o a.inst
  - instruments a binary. Other flags –T <tags>, -f <selective instrumentation file>
- \*% tau\_run -1 /path/to/libhdf5.so.310 -o libhdf5.so.310
- instruments a DSO
- \$ tau\_exec ./a.out
- executes the uninstrumented application with the instrumented shared object.
- Works on x86\_64 with -g (-O2 has issues). Issues with aarch64:
- https://github.com/dyninst/dyninst/issues/1708 and https://github.com/dyninst/dyninst/pull/1712
- To use with DyninstAPI 13 on x86\_64:
- I. Load spack: spack/share/spack/setup-env.sh
- 2. Install dyninst: spack install dyninst@13 %gcc@11
- 3. Configure tau with dyninst:
  - 3.1 spack find -p dyninst boost tbb elfutils
  - 3.2 Copy the paths for each package into the configure line
- 3.3 ./configure -bfd=download -dyninst=<dir> -tbb=<dir> -boost=<dir> -elf=<dir>; <set paths>; make install

# Installing TAU on your laptop for paraprof (GUI)

#### Microsoft Windows

- Install Java from Oracle.com
- http://tau.uoregon.edu/tau.exe
- Install, click on a ppk file to launch paraprof

#### macOS

- Install Java 11.0.3:
  - Download <u>http://tau.uoregon.edu/java.dmg</u>
  - If you have multiple Java installations, add to your ~/.zshrc (or ~/.bashrc as appropriate):
  - export PATH=/Library/Java/JavaVirtualMachines/jdk-11.0.3.jdk/Contents/Home/bin:\$PATH
  - java -version
- Download and install TAU (copy to /Applications from dmg):
  - http://tau.uoregon.edu/tau.dmg
  - export PATH=/Applications/TAU/tau/apple/bin:\$PATH
  - paraprof app.ppk &
- macOS (arm64, M1/M2)
  - http://tau.uoregon.edu/java\_arm64.dmg
  - http://tau.uoregon.edu/tau\_arm64.dmg

#### Linux (http://tau.uoregon.edu/tau.tgz)

- ./configure; make install; export PATH=<taudir>/x86\_64/bin:\$PATH
- paraprof app.ppk &

# TAU Execution Command (tau\_exec)

Uninstrumented execution

• % mpirun -np 256 ./a.out

Track GPU operations

- % mpirun –np 256 tau\_exec –rocm ./a.out
- % mpirun –np 256 tau\_exec –cupti ./a.out
- % mpirun –np 256 tau\_exec –opencl ./a.out
- % mpirun –np 256 tau\_exec –openacc ./a.out
- % mpirun –np 256 tau\_exec –l0 ./a.out
- Track MPI performance
  - % mpirun -np 256 tau\_exec ./a.out

Track I/O, and MPI performance (MPI enabled by default)

- % mpirun -np 256 tau\_exec -io ./a.out
- Track OpenMP and MPI execution (using OMPT for Intel v19+ or Clang 8+)
  - % export TAU\_OMPT\_SUPPORT\_LEVEL=full;
  - % mpirun –np 256 tau\_exec –T ompt,mpi -ompt ./a.out
- Track memory operations
  - % export TAU\_TRACK\_MEMORY\_LEAKS=1
  - % mpirun –np 256 tau\_exec –memory\_debug ./a.out (bounds check)
- ■Use event based sampling (compile with –g)
  - % mpirun –np 256 tau\_exec –ebs ./a.out
  - Also -ebs\_source=<PAPI\_COUNTER> -ebs\_period=<overflow\_count> -ebs\_resolution=<file | function | line>

#### **TAU's 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

#### **Runtime Environment Variables**

Environment Variable	Default	Description
TAU_METRICS		Setting to a comma separated list generates other metrics. (e.g., ENERGY,TIME,P_VIRTUAL_TIME,PAPI_FP_INS,PAPI_NATIVE_ <event>:<subevent>)</subevent></event>
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_EBS_RESOLUTION	line	Setting to "function" or "file" changes the sampling resolution to function or file level respectively.
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	1	Setting to 1 is necessary for event based sampling to resolve addresses with OMPT. Setting to 0 allows the user to do offline address translation.
TAU_EVENT_THRESHOLD	0.5	Define a threshold value (e.g., .25 is 25%) to trigger marker events for min/max

#### **Runtime Environment Variables**

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's Analysis Tools: ParaProf

# **TAU Analysis**



#### **ParaProf Profile Analysis Framework**



# **TAU Analysis Tools: paraprof**

	TAU: ParaProf	Manager	۲ ۲
	Applications	TrialField	Value
Launch paraprot	Standard Applications	Name	bt_ompt.ppk
		Application ID	0
		Experiment ID	0
	V 🗾 Default Exp	Trial ID	0
% paraprof	🔻 🥥 bt_ompt.ppk	CPU Cores	8
	∠ S TIME	CPU MHz	2600.000
	Default (idbc:b2:/Users/sameer/.ParaProf/perfdmf/perfdmf:AUTO_SERVER=TRUE)	CPU Type	Intel(R) Xeon(R) CPU E5-2670 0 @ 2.60GHz
		CPU Vendor	GenuineIntel
		CWD	/scratch/sameer/NPB3.3-MZ-MPI/bin
		Cache Size	20480 КВ
		Command Line	./bt-mz_C.8
		Executable	/scratch/sameer/NPB3.3-MZ-MPI/bin/bt-mz_C.8
		File Type Index	0
		File Type Name	ParaProf Packed Profile
Metric		Hostname	frog9
mourio		Local Time	2015-05-18T00:37:38+02:00
		MPI Processor Name	frog9
		Memory Size	65944056 kB
		Node Name	frog9
		OMP_CHUNK_SIZE	1
		OMP_DYNAMIC	off
		OMP_MAX_THREADS	4
		OMP_NESTED	off
		OMP_NUM_PROCS	4
		OMP_SCHEDULE	UNKNOWN
		OS Machine	x86_64
		OS Name	Linux
		OS Release	2.6.32-279.5.2.bl6.Bull.33.x86_64
		OS Version	#1 SMP Sat Nov 10 01:48:00 CET 2012

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## **ParaProf Manager Widow: scout.cubex**



## **Paraprof main window**



# **Paraprof main window**



#### **ParaProf Profile Browser**



## **Paraprof main window**



Each routine occupies its own space. Can see the extent of imbalance across all threads.

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#### **Paraprof node window (function barchart window)**

		TAU: ParaProf: node 0, thread 1 - bt_ompt.ppk
	Metric: TIME Value: Exclusive Units: seconds	
Exclusive time spent in each code region (OpenMP loop) is shown here for MPI rank 0 thread 1	8.214 8.038 7.899 3.549 2.223 0.200 0.18 0.14 0.09 0.08 0.07 0.06 0.06 0.06 0.06 0.04	<ul> <li>OpenMP_LOOP: L_z_solve_43_par_region0_2_44 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f] {43,0]</li> <li>OpenMP_LOOP: L_y_solve_46_par_region0_2_43 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/x_solve.f] {45,0]}</li> <li>OpenMP_LOOP: L_compute_rhs_28_par_region0_2_306 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/k_solve.f] {45,0]}</li> <li>OpenMP_LOP: L_compute_rhs_28_par_region0_2_306 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/k_solve.f] {45,0]}</li> <li>TAU application</li> <li>OpenMP_IMPLICIT_TASK: L_compute_rhs_28_par_region0_2_306 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/rhs.f] {28,0]}</li> <li>OpenMP_LOOP: L_add_22_par_loop0_2_19 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/rhs.f] {28,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_255_par_loop1_2.306 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/rhs.f] {28,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_204_par_region0_2_306 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/rch.dpc.f] {25,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_215_par_loop1_2.211 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_214_par_loop0_2_176 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_214_par_loop0_2_176 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_214_par_loop0_2_2176 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_LOOP: L_copy_x_face_215_par_loop1_2_211 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_LOP: DCOP: L_copy_x_face_215_par_loop1_2_211 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_IMPLICIT_TASK: L_copy_x_face_215_par_loop1_2_2176 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_IMPLICIT_TASK: L_copy_x_face_215_par_loop1_2_2176 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {204,0]}</li> <li>OpenMP_IMPLICIT_TASK: L_copy_x_face_215_par_loop1_2_247 [[/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/exch.qbc.f] {2</li></ul>
	0.01 0.01 0.01	<ul> <li>3   OpenMP_BARRIER: L_x_solve_46_par_region0_2_43 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/x_solve.f} {46,0}]</li> <li>3   OpenMP_BARRIER: L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {43,0}]</li> <li>2   OpenMP_BARRIER: L_add_22 par_loop0_2_19 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/add.f} {22,0}]</li> </ul>
	0.00	04       OpenMP_LOOP: L_error_norm27par_region0_2_148 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/error.f} {27,0}]         01       OpenMP_IMPLICIT_TASK: L_initialize28par_region0_2_193 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/initialize.f} {28,0}]

#### **Instrumenting Source Code with PDT and Opari**


#### **ParaProf: Node view in a callpath profile**

	TAU: Para	aProf: node O, thread O - profile.cubex -		×
File Options Windows Help				
File Options Windows Help Metric: Time Value: Exclusive Units: seconds 3.71 3.71 3.593 3.593 3.593 3.55 3.55	0.4 0.398 0.383 0.381 0.352 0.298 0.298 0.298 0.298 0.298	<pre>MAIN =&gt; adi_ =&gt; y_solve_ =&gt; !\$omp parallel @y_solve.f:43 =&gt; !\$omp do @y_solve.f !\$omp do @y_solve.f:52 MAIN =&gt; adi_ =&gt; z_solve_ =&gt; !\$omp parallel @z_solve.f:43 =&gt; !\$omp do @z_solve.f: !\$omp do @z_solve.f:52 MAIN =&gt; adi_ =&gt; x_solve_ =&gt; !\$omp parallel @x_solve.f:46 =&gt; !\$omp do @x_solve.f: !\$omp do @y_solve.f:54 !\$omp do @rhs.f:191 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:1 !\$omp do @rhs.f:80 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:8 !\$omp parallel @rhs.f:28 !\$omp parallel @rhs.f:28 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:8 !\$omp parallel @rhs.f:28 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37</pre>	52 52 54 91 0	
	0.28 0.279 0.261 0.259 0.228 0.227 0.214 0.214 0.214	<pre>isomp do @rhs.f:37 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:3 !\$omp do @rhs.f:301 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:3 !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:6 MAIN_ =&gt; mpi_setup_ =&gt; MPI_Init_thread MAIN_ =&gt; exch_qbc_ =&gt; copy_x_face_</pre>	7 01 2	
	0.161 0.16 0.15 0.15 0.15 0.141 0.14 0.127 0.127 0.123 0.103 0.103 0.094	<pre>copy_x_face_ MAIN=&gt; exch_qbc_ =&gt; copy_y_face_ copy_y_face_ MAIN=&gt; exch_qbc_ exch_qbc_ !\$omp do @rhs.f:384 MAIN=&gt; adi_=&gt; compute_rhs_=&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:3 MAIN=&gt; exch_qbc_=&gt; MPI_Waitall MPI_Waitall MAIN=&gt; adi_ adi_ MAIN_ =&gt; adi =&gt; add =&gt; !\$omp parallel @add.f:22 =&gt; !\$omp parallel do @add.f:2</pre>	84	
	0 0 0 4 🔲	Item parallel de Godd fr22		-

#### ParaProf: Add thread to comparison window



#### Paraprof Thread Statistics Table with TAU\_SAMPLING=1



#### **ParaProf: Thread Statistics Table**

File Options Windows Help					
Time					
Name	Exclusive Time 🗸 🥿	Inclusive Time	Calls	Child Calls	
	5.817	5.817	3,216	0	
	5,657	5.657	3,216	0	
	5,609	5,609	3,216	0	
	0.609	20	3,232	0 _	
	0.583		3,232	0	
– MPI_Waitall	0.402	6	603	0	
	0.402				
🕈 🗖 !\$omp do @rhs.f:301	0.36				
	0.026	Click to	o sort bv	a given metric.	dra
\$omp implicit barrier	0				
	0.343	and r	nove to	rearrange colur	nns
<mark>e =</mark> !\$omp do @rhs.f:62	0.225				
	0.004	0.004	3,210	U	
-somp implicit barrier	0	0	16	0	
– MPI_Init_thread	0.218	0.218	1	0	
- <mark>-</mark> !\$omp do @rhs.f:384	0.199	0.199	3,232	0	
🗠 🗖 !\$omp parallel do @add.f:22	0.099	0.111	3,216	3,216	
- <mark>-</mark> !\$omp do @rhs.f:428	0.069	0.069	3,232	0	
- MPI_Isend	0.043	0.043	603	0	
	0.04	0.04	32	0	
🗠 🗖 !\$omp parallel @rhs.f:28	0.03	2.536	3,232	51,712	
\$000 states and a state of the state of t	0.021	0.029	6,432	6,432	
\$000 parallel do @exch_qbc.f:255	0.02	0.033	6,432	6,432	
\$000 states a state of the s	0.02	0.053	6,432	6,432	
Isomp parallel @exch qbc.f:244	000		FinderScre	enSnapz003.png	

# VI-HPS

# ParaProf

- Click on Columns:
- to sort by incl time
- Open binvcrhs
- Click on Sample

TAU: ParaProf: Statistics for: node 0 - /rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/bin					
File Options Windows Help					
Name	Exclusive TIME	Inclusive TIME V	Calls (	Child Calls	
ዮ 🗖 .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	o	
SUMMARY] matvec_sub_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-	0.49	0.49	49	0	
[SUMMARY] Ihsinit_ [ {/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 Thread Statistics Table**

	TAU: ParaProf: Statistics for: node 2, thread 0 - bt_ebs.ppk				
	Name	Exclusive TIME	Inclusive TIME 🗸	Calls	Child Calls
	TAU application	1.754	36.26	1	88,049
	OpenMP_PARALLEL_REGION: L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {43,0}]	0.061	8.692	6,432	12,864
	OpenMP_IMPLICIT_TASK: L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {43,0}]	0.04	8.568	6,432	6,432
	OpenMP_LOOP: L_z_solve43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {43,0}]	8.528	8.528	6,432	C
	[CONTEXT] OpenMP_LOOP: L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {43,0}]	0	9.23	847	C
	SUMMARY] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f}]	3.67	3.67	340	C
	SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f}]	3.67	3.67	340	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {419}]	0.22	0.22	21	C
	SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {58}] Show Function Bar	Chart 0.17	0.17	16	C
	Show Function Histical	togram 0.16	0.16	12	C
	SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {123}]	lor 0.11	0.11	11	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {193}]	0.08	0.08	5	0
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {126}]	0.07	0.07	/	(
RIGHT CIICK	[SAMPLE] L_Z_SOIVE_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/Z_SOIVE.f} {247}]	0.07	0.07	6	
bara and	[SAMPLE] L_Z_SOIVe_45_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/Z_SOIVe.1} {158}]	0.06	0.06	5	
nere and	$[SAMPLE] L_2_Solve_43_par_region0_2_44 [{/scratch/samper/NPB3.3-MZ-MPI/BT-MZ/2_Solve.1} {S13}]$	0.00	0.00	4	
abaaaa	$[SAMPLE] L_2_Solve_43_pal_region0_2_44 [(/scratch/sameer/NPB3_3_M7_MPL/BT_M2/2_solve_1) [250f]$	0.00	0.00	4	
choose	$ [SAMPLE] L_2_Solve_43  \text{par-region0} = 2.44 \left[ \frac{1}{\text{scratch}/\text{sameer}} - MPR_3 - MPL/RT_MZ/z_solve_1 \left\{ 191 \right\} \right] $	0.05	0.05	3	
"Show	$ [SAMPLE] L_2_Solve13_par_region0_2_14 [(/scratch/sameer/NPB3_3_MZ_MPL/BT_MZ/z_solve_f) [81]] $	0.05	0.05	4	(
SHOW	$[SAMPLE] L z solve 43 par region 0 2 44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z solve.f} {301}]$	0.05	0.05	5	C
Sourco	SAMPLE L z solve 43 par region 2 44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z solve.f} {67}]	0.05	0.05	5	C
Source	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {175}]	0.04	0.04	4	C
Code" for a	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {89}]	0.04	0.04	4	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {55}]	0.04	0.04	4	C
samnla	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {275}]	0.04	0.04	4	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {129}]	0.04	0.04	4	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {168}]	0.04	0.04	4	C
	[SAMPLE] L_z_solve_43_par_region0_2_44 [{/scratch/sameer/NPB3.3-MZ-MPI/BT-MZ/z_solve.f} {238}]	0.04	0.04	4	C

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### ParaProf

X TAU: ParaProf: Statistics for: node 0 - /rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/bin

File Ontions Windows Help

Name Exclus	sive TIME	Inclusive TIME 🗸	Calls	Child Calls
P . 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/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
Show Source Code [SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f] Show Source Code	0.09	0.09	9	0
– [SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} Show In Statistics T/	able 0.09	0.09	9	0
- Campbell SAMPLE   binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} Show Function Histor	ogram 0.06	0.06	6	0
SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} Show Function Bar (	Chart 0.06	0.06	6	0
– 🔄 [SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} Assign Function Col	lor 0.06	0.06	6	0
SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} Reset to Default Co	olor 0.06	0.06	6	0
[SAMPLE] binvcrhs_ [{/rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} 1244}]	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 [{/nvthfs/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
SAMPLEL binvcrbs. [{/wthfs/rz/cluster/work/bpclab17/NPB3.3-MZ-MPI/BT-MZ/solve_subs.f} {412}]	0.03	0.03	3	0 //

## **Statement Level Profiling with TAU**



#### **ParaProf Comparison Window**



#### TAU – Event Based Sampling (EBS)



% export TAU\_SAMPLING=1

## **Examples: Callstack Sampling in TAU**

Name	Inclusive TIME V	Calls
.TAU application	79.592	
MPI_Recv()	75.607	6,8
CONTEXT] MPI_Recv()	74.848	1,4
UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN_ [{/gpfs/mira-home/sameer/gamess-theta-	t 26.196	5
UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sameer/g	21.7	4
UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@]	<b>11.85</b>	2
UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_init.c.113 [@] ddi_init_ [{/gpfs/mira-home/yuri/dist/G	i 8.701	1
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	1
UNWIND] /lib64/libc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu//sysdeps/x86_64/start.S} {118}]	0.2	
[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	
[UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1ge7db4a2.ari/lib64/libugni.so.0.6.0.0] [@] UNRESOLVED UNKNOWN	0.15	
[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	
[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 <b>0.05</b>	
MPI_Finalize()	3.601	
MPI_Send()	0.122	6,8
MPI_Init_thread()	0.112	
CONTEXT] .TAU application	0.05	
MPI_Bcast()	0.014	
MPI_Allgather()	0.004	
MPI_Barrier()	0.003	
MPI_Comm_create()	0.002	
MPI_Gather()	0.002	
MPI_Comm_split()	0.002	
MPI_Group_intersection()	0.001	
MPI_Comm_group()	0.001	
MPI_Group_incl()	0	
MPI_Comm_rank()	0	
MPI Comm size()	0	

## **UNWINDING CALLSTACKS**

TAU: ParaProf: Statistics for: n,c,t 2,0,0 - gamess_unw_call_ebs.ppk		
Name	nclusive TIME V	Calls
TAU application	79.592	1
	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 [{/c	21.45	429
[UNWIND] /opt/cray/ugni/6.0.14-6.0.4.0_14.1_ge7db4a2.ari/lib64/libugni.so.0.6.0.0 [@] MPID_nem_gni_poll [{/	15.95	319
[SAMPLE] GNI_SmsgGetNextWTag [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1ge7db4a2.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_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/libmpich_intel/16.0/lib/lib/lib/libmpich_intel/16.0/lib/lib/lib/lib/lib/lib/lib/lib/lib/lib	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_14.1ge7db4a2.ari/lib64/libugni.so.0.6.0} {0}]	0.2	4
UNWIND] [/opt/cray/ugni/6.0.14-6.0.4.0_14.1ge7db4a2.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_CH31_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

% export TAU\_SAMPLING=1; export TAU\_EBS\_UNWIND=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
Tecv()	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-tau/object/unport.f.410 [@]	- 26.196	524
[UNWIND] /gpfs/mira-home/yuri/dist/Github/gamess-theta-tau/ddi/src/ddi_fortran.c.67 [@] beging_ [{/gpfs/mira-home/sameer/e	g 21.7	434
🔻 🗖 [UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/gamess.f.538 [@] main [{/gpfs/mira-home/sameer/gamess-theta-t	a 11.85	237
🔻 🗖 [UNWIND] /gpfs/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [@] MAIN [{/gpfs/mira-home/sameer/gamess-the	t 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/yu	r 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	s 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} {	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.	0.2	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/C	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_14.1ge7db4a2.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

#### **Deep Learning: Tensorflow**

TAU: ParaProf: Statistics for: node 0, thread 8 - nt3_baseline_keras2.ppk		
Name	Inclusiv	Calls ⊽
TAU application	519.211	1
CONTEXT] .TAU application	509.222	50,915
<b>[</b> SAMPLE] Eigen::internal::gebp_kernel <float, 0="" 0,="" eigen::internal::blas_data_mapper<float,="" float,="" long,="">,</float,>	240.632	24,089
[SAMPLE]pthread_cond_wait [{} {0}]	86.384	8,634
[SAMPLE] Eigen::internal::gemm_pack_rhs <float, eigen::internal::tensorcontractionsubmapper<float,="" long,="" lor<="" p=""></float,>	51.345	5,135
[SAMPLE] Eigen::internal::gemm_pack_rhs <float, eigen::internal::tensorcontractionsubmapper<float,="" long,="" lor<="" p=""></float,>	24.375	2,416
[SAMPLE] void tensorflow::SpatialMaxPoolWithArgMaxHelper <eigen::threadpooldevice, float="">(tensorflow::OpK</eigen::threadpooldevice,>	16.301	1,630
[SAMPLE]memset_sse2 [{} {0}]	13.446	1,336
[SAMPLE] Eigen::TensorEvaluator <eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>, 1ul&gt; co</eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>	5.99	599
[SAMPLE] long Eigen::internal::operator/ <long, false="">(long const&amp;, Eigen::internal::TensorIntDivisor<long, false)<="" p=""></long,></long,>	5.843	585
[SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<li="" long),=""></void>	5.377	538
[SAMPLE] floatvector Eigen::TensorEvaluator <eigen::tensorbroadcastingop<eigen::indexlist<int, eigen::typ<="" p=""></eigen::tensorbroadcastingop<eigen::indexlist<int,>	4.862	487
[SAMPLE] Eigen::TensorEvaluator <eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>, 1ul&gt; co</eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>	4.775	478
[SAMPLE] Eigen::TensorEvaluator <eigen::tensorassignop<eigen::tensormap<eigen::tensor<float, 1,="" long=""></eigen::tensorassignop<eigen::tensormap<eigen::tensor<float,>	4.037	404
[SAMPLE] Eigen::internal::gemm_pack_lhs < float, long, Eigen::internal::TensorContractionSubMapper < float, lon	3.679	367
[SAMPLE] Eigen::internal::EvalRange <eigen::tensorevaluator<eigen::tensorassignop<eigen::tensormap<eigen< p=""></eigen::tensorevaluator<eigen::tensorassignop<eigen::tensormap<eigen<>	2.981	298
[SAMPLE] tensorflow::MaxPoolingOp <eigen::threadpooldevice, float="">::SpatialMaxPool(tensorflow::OpKernelCo</eigen::threadpooldevice,>	2.915	295
[SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<<="" long),="" p=""></void>	2.91	291
[SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<<="" long),="" p=""></void>	2.772	277
[SAMPLE] Eigen::internal::gemm_pack_lhs <float, eigen::internal::tensorcontractionsubmapper<float,="" lon<="" long,="" p=""></float,>	2.481	248
[SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<<="" long),="" p=""></void>	2.148	215
■[SAMPLE] void Eigen::internal::call_dense_assignment_loop <eigen::map<eigen::matrix<float, -1,="" -1;<="" 0,="" td=""><td>2.008</td><td>197</td></eigen::map<eigen::matrix<float,>	2.008	197
[SAMPLE] Eigen::NonBlockingThreadPoolTempl <tensorflow::thread::eigenenvironment>::WorkerLoop(int) [{/hc</tensorflow::thread::eigenenvironment>	1.999	200
[SAMPLE] Eigen::internal::ptranspose(Eigen::internal::PacketBlock < floatvector, 4>&) [{crtstuff.c} {0}]	1.919	192
[SAMPLE] Eigen::internal::gemm_pack_rhs <float, eigen::internal::tensorcontractionsubmapper<float,="" long,="" lor<="" p=""></float,>	1.607	160
[SAMPLE] Eigen::TensorEvaluator <eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>, 1ul&gt; co</eigen::tensorcontractionop<eigen::array<eigen::indexpair<long>	1.518	152

#### % tau\_python -ebs nt3\_baseline\_keras2.py (CANDLE)



#### **Sampling Tensorflow**

	TAU: ParaProf: Function Data Window: nt3_baseline_keras2.ppk
Name: .TAU app Eigen::internal:: Eigen::internal:: Eigen::TensorEv Eigen::Array <lor false&gt;::operator Eigen::TensorEv Eigen::MakePoin Eigen::array<lor long) [{crtstuff.c Metric Name: TI Value: Exclusive Units: seconds</lor </lor 	<pre>lication =&gt; [CONTEXT] .TAU application =&gt; [SAMPLE] gemm_pack_rhs <float, 0,="" 1,="" 2,="" <eigen::tensor="" <eigen::tensormap="" <float="" <float,="" aluator="" const,="" long="" long,="" tensorcontractionsubmapper="">, 0, iter&gt; const, Eigen::ThreadPoolDevice&gt;, Eigen::array <long, 1ul="">, ng, 1ul&gt;, 8, false, false, 0, Eigen::MakePointer&gt;, 4, 0, false, '()(float*, Eigen::internal::TensorContractionSubMapper <float, 0,="" 1,="" 2,="" <eigen::tensor="" <eigen::tensormap="" <float="" aluator="" const,="" long="" long,="">, 0, iter&gt; const, Eigen::ThreadPoolDevice&gt;, Eigen::array <long, 1ul="">, ng, 1ul&gt;, 8, false, false, 0, Eigen::Tensor <float 1,="" 2,="" const,="" long="">, 0, iter&gt; const, Eigen::ThreadPoolDevice&gt;, Eigen::array <long, 1ul="">, ng, 1ul&gt;, 8, false, false, 0, Eigen::MakePointer&gt; const&amp;, long, long, long, :} {0} ME</long,></float></long,></float,></long,></float,></pre>
53.463 50.094 53.463 50.193 52.872 51.145 52.442 52.618 51.345	15.44       std. dev.         5.144       mean         max       max         0.02       min         node 0, thread 1       node 0, thread 2         node 0, thread 3       node 0, thread 4         node 0, thread 5       node 0, thread 5         node 0, thread 7       node 0, thread 47         0.05       node 0, thread 47         0.04       node 0, thread 5         node 0, thread 5       node 0, thread 55         node 0, thread 5       node 0, thread 5         node 0, thread 5       node 0, thread 5

## **Event Based Sampling (EBS)**



## **Callsite Profiling and Tracing**



% export TAU\_CALLSITE=1

#### **CALLPATH THREAD RELATIONS WINDOW**

Metric Sorted Units: s	Name: TIME By: Inclusive econds			
	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 [0] ddi_
	0	26.196	524/763	[UNWIND] /gpis/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [0] MAIN_ [{/gpis/mira-home/sameer/gamess-theta-tau/object/unport.f.410 [0] MAIN_ [{/gpis/mira-home/sameer/gamess-tau/sameer/gameer
	0.2	0.2	4/138	[SAMPLE] GNII_DIaProgress [{/opt/cray/ugni/6.0.14-6.0.4.0_14.1_ge7db4a2.ari/lib64/libugni
	0	5.75	115/1484	[UNWIND] /gpts/mira-nome/yurl/dist/Github/gamess-theta-tau/ddi/src/ddi server.c.99 [@] DDI
	0	0.2	4/5	UNWIND] /11b64/11bc-2.22.so.0 [@] _start [{/home/abuild/rpmbuild/BUILD/glibc-2.22/csu//s
	0	11.85	237/239	[UNWIND] / gpts/mira-nome/sameer/gamess-theta-tau/object/gamess.t.538 [0] main [{/gpfs/mira-
	0.051	0.051	1/2/3	[SAMPLE] GNI_CQUEETEVENT [{/Opt/Cray/ugn1/6.0.14-b.0.4.0_14.1_ge/db4a2.art//lb64/lbugn1.8c
	U	0.05	1/119/	UNWIND / OPT/CTAY/PE/MPT//.6.3/gnl/mpich-intel/i6.0/iib/iibmpich_intel.so.3.0.1.0 [0] MPI
	0	0.15	3//	[UNWIND] [/opt/cray/ugn1/6.0.14-6.0.4.0_14.1_ge/db42/ar1/11664/1160gn1.50.0.6.0.0] [0] UN
	U	21.7	434/119/	[UNWIND] /gpis/mira-nome/yuri/dist/Gitnub/gamess-theta-tau/ddi/src/ddi_fortran.C.67 [0] beg

#### **CALLPATH THREAD RELATIONS WINDOW**

•••			TA	\U: ParaProf: Call Path Data n,c,t, 2,0,0 - gamess_unw_call_ebs.ppk
Metric Sorted Units: s	Name: TIME By: Exclusive econds			
	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_CR3:
	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_14.1ge7db4a2.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_14.1ge7db4a2.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_14.1ge7db4a2.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_14.1ge7db4a2.ari/lib64/libugni.so.0.6.0.0]
>	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_14.1ge7db4a2.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_14.1ge7db4a2.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_14.1ge7db4a2.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_14.1ge7db4a2.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/lil
	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()

#### **ParaProf: Callpath Thread Relations Window**

	TAU: ParaProf: Call Path Data n,c,t, 0,0,0 - scout.cubex			_ 🗆 ×	
ile Opt	ions Windows H	elp			
Metric N	lame: Time				
Sorted I	By: Exclusive				
Jnits: s	econds				
					<b>_</b>
	0.04	0.04	32/32	!\$omp parallel @initialize.f:28	
>	0.04	0.04	32	!\$omp do @initialize.f:50	
	0.03	2 536	3232/3232	compute the	
>	0.03	2,536	3232/ 3232	l¢omp parallal @rbc fu28	
	0.05 0.9F-4	0.9F-4	3232 (3232	Isomp master Orbs f.424	
	0 225	0 228	3232/3232	Isomp do Orbs f:62	
	0.002	0.220	3232/3232	Isomp do gristroz	
	0.002	0.002	3232/3232	Isomp master @rhst1174	
	A. 199	A. 100	3232/3232	Isomo do Orbs. f: 384	
	0.002	0.002	3232/3232	l\$omn_master_@rhs.f:183	
	0.343	0.343	3232/3232	Isomo do @rhs.f:37	
	0.016	0.016	3232/3232	Isomn do @rhs.f:372	
	0.014	0.027	3232/3232	!\$omn_do_@rhs.f:413	
	0.609	0.609	3232/3232	!\$omp do @rhs.f:191	
	0.36	0.386	3232/3232	!\$omp do @rhs.f:301	
	0.583	0.583	3232/3232	!\$omp do @rhs.f:80	
	0.019	0.019	3232/3232	!\$omp do @rhs.f:400	
	0.006	0.006	3232/51680	!\$omp implicit barrier	
	0.069	0.069	3232/3232	!\$omp_do_@rhs.f:428	
	0.015	0.015	3232/3232	!\$omp_do_@rhs.f:359	
	0.021	0 020	6432/6432	Isomo parallel Geych dbc fr215	
>	0.021	0.029	6432	Isomn narallel do @exch nbc.f:215	
	0.007	0.007	6432/51680	Isomn implicit harrier	
	01007	01007	5132/01000		
	0.02	0.033	6432/6432	Isomn narallel @exch obc.f:255	
>	0.02	0.033	6432	Isomn parallel do @exch obc.f:255	
-	0.013	0.013	6432/51680	somn imnlicit harrier	
	VIVIS	VIV13	a long o toov	the sub-rub cross particular	

## Callsite Profiling and Tracing (TAU\_CALLSITE=1)



#### **Identifying MPI Collective Sync Wait in Thread Callpath Relations**

TAU: ParaProf: Call Path Data n,c,t, 118,0,0 - 128\_d3d.ppk Metric Name: TIME Sorted By: Exclusive Units: seconds Inclusive Calls/Tot.Calls Name[id] Exclusive 1191.772 1/1i:SETUP 1099.614 1099.614 1191.772 1 i:LOAD --> 0.006 92.158 3/9543 MPI Allreduce() 9.8E-4 9.8E-4 11/15177 MPI\_Gatherv() 1.448 43/15177 MPI Gather() 1.448 MPI\_Alltoall() 15.353 15.353 46/15177 89.821 89.821 MPI\_Bcast() 4311/15177 MPI\_Allgather() 6.777 6.777 195/15177 MPI Reduce() 68.678 68.678 991/15177 9.179 9.179 12/15177 MPI Comm dup() MPI\_Allgatherv() 0.125 0.125 25/15177 382.861 382.861 MPI Allreduce() 9543/15177 574.243 574.243 15177 MPI Collective Sync --> 2.507 2.508 10/186 DISTRIBUTE\_F0G 2.433 2.434 10/186 F\_UPD\_F0\_SP 5.156 5.158 20/186 F0\_CHARGE\_SEARCH\_INDEX 5.505 5.507 22/186 PULLBACK WEIGHT 24.86 UPDATE PTL WEIGHT 24.872 102/186 0.473 0.473 2/186 MAIN LOOP 4.975 4.977 20/186 DIAG fØ PORT1 PTL 45.91 45.93 186 copy ptl to device --> Kokkos::parallel\_for set\_buffer\_particles\_d [type = Cuda, device = 0] 0.02 0.02 186/272

#### MPI Collective Sync is the time spent in a barrier operation inside a collective

#### **Thread Comparison Window**



#### **TAU – Context Events**

000	TAU: ParaProf: Context Event	s for thread: n,c,t, 1,0,0 -	samarc_obe_4p	_iomem_cp.ppk				
Name 🗸			Total	MeanValue Nu	umSamples Mi	nValue	MaxValue	Std. Dev.
▼ .TAU application								
▶ read()		1 1 1 1	(					
▶ fopen64()	Write ha	andwidth	ner t					
fclose()								
▼ OurMain()								
malloc size			25,235	1,097.174	23	11	12,032	2,851.143
free size			22,707	1,746.692	13	11	12,032	3,660.647
OurMain [{wrapper.py}{3}]								
▶ read()								
malloc size			3,877	323.083	12	32	981	252.7
free size								123
fopen64()				ton to	anah	fila		
▶ fclose()		DVLE	es wri	llen lo	) each	me		
<pre><module> [{obe.py}{8}]</module></pre>		_ / ~ ~	·••••••••			••••		
writeRestartData [{samarcInterface.py}{145}]								
samarcWriteRestartData								
▼ write()	$\checkmark$							
WRITE Bandwidth (MB/s) <file="sama< td=""><td>rc/restore.00002/nodes.0</td><td>00004/proc.00001"&gt;</td><td></td><td>74.565</td><td>117</td><td>0</td><td>2,156.889</td><td>246.38</td></file="sama<>	rc/restore.00002/nodes.0	00004/proc.00001">		74.565	117	0	2,156.889	246.38
WRITE Bandwidth (MB/s) <file="sama< td=""><td>rc/restore.00001/nodes.0</td><td>00004/proc.00001"&gt;</td><td><math>\checkmark</math></td><td>77.594</td><td>117</td><td>0</td><td>1,941.2</td><td>228.36</td></file="sama<>	rc/restore.00001/nodes.0	00004/proc.00001">	$\checkmark$	77.594	117	0	1,941.2	228.36
WRITE Bandwidth (MB/s)				76.08	234	0	2,156.889	237.55
Bytes Written <file="samarc restore.0"<="" td=""><td>00002/nodes.00004/proc</td><td>.00001"&gt;</td><td>2,097,552</td><td>17,927.795</td><td>117</td><td>1</td><td>1,048,576</td><td>133,362.946</td></file="samarc>	00002/nodes.00004/proc	.00001">	2,097,552	17,927.795	117	1	1,048,576	133,362.946
Bytes Written <file="samarc restore.<="" td=""><td>00001/nodes.00004/proc</td><td>.00001"&gt;</td><td>2,097,552</td><td>17,927.795</td><td>117</td><td>1</td><td>1,048,576</td><td>133,362.946</td></file="samarc>	00001/nodes.00004/proc	.00001">	2,097,552	17,927.795	117	1	1,048,576	133,362.946
Bytes Written			4,195,104	17,927.795	234	1	1,048,576	133,362.946
▶ open64()								

#### **ParaProf with Optimized Instrumentation**



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

TAU: ParaProf: /rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/bin	TAU: ParaProf: Selective Instrumentation File Generator
File         Options         Windows         Help           Export Profile	Output File: /rwthfs/rz/cluster/work/hpclab17/NPB3.3-MZ-MPI/bin/select.tau
Convert to Phase Profile Create Selective Instrumentation File Add Mean to Comparison Window	Exclude Throttled Routines
Save Preferences	Exclude Lightweight Routines
Print Close This Window	Lightweight Routine Exclusion Rules
Exit ParaProf!	Microseconds per call: 10
node 4 node 5 node 6 no	Number of calls: 100000
node 7	Excluded Routines
	Ihsinit_         exact_solution_         matvec_sub_         matmul_sub_         binvcrhs_         binvrhs_
	save Merge close

## **Paraprof 3D visualization window**



#### **ParaProf: 3D Visualization Window Showing Entire Profile**



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#### **Callsite Profiling and Tracing**



#### **Callsite Profiling and Tracing**

• • •	TAU	AU: ParaProf: 3D Visualizer: lu_callsite.ppk	
4 2	🔵 Triangle Me	Mesh	
	🗿 Bar Plot		
	Scatter Plot	ot	
		Plot	
ſ			
	Height Metric	c	
	Exclusive		-
1189 B	Color Metric		
5,00	Exclusive		-
		[CALLSITE] MPI_Recv() [@] [exchange_1_] [{/lus/theta-fs0/projects/Tools/tau/workshop/NPB3.1/LU/exchange_1.f} {68}]	
	Function		
	Thread	0	
and a few a The few and a few and The few and a few and The few and a few			
and the second	Height value	e 12.627 seconds	
	Color value	12.627 seconds	
		Scalar Blat Avec Color Bandar	
		States Piot Axes Color Render	-
	height:	0 14.695	
		seconds	
	color:	0 14.695	
		seconds	

#### **Parallel Profile Visualization: ParaProf**



 $\times$ 

#### **ParaProf 3D Communication Matrix**



#### % export TAU\_COMM\_MATRIX=1

#### **ParaProf: 3D Scatter Plot**



#### **ParaProf: Score-P Profile Files, Database**

TAU: ParaProf Manager		_ 🗆 ×
File Options Help		
Applications	TrialField	Value
ዮ 🗂 Standard Applications	Name	profile.cubex
P-□ Default App	Application ID	0
🖕 🔚 Default Exp	Experiment ID	0
🔶 🥅 profile.cubex	Trial ID	0
	File Type Index	9
- S Minimum Inclusive Time	File Type Name	Cube
— 🥯 Maximum Inclusive Time		
- O PAPI_TOT_CYC		
- O PAPI_TOT_INS		
- PAPI_FP_INS		
- • ru minfit		
– 🔍 ru majflt		
– • ru <sup>-</sup> nswap		
– S ru_inblock		
– 🥯 ru_oublock		
– 🔍 ru_msgsnd		
– 🥥 ru_msgrcv		
– 🦉 ru_nsignals		
- • ru_nvcsw		
<ul> <li>bytes_senic</li> <li>bytes_received</li> </ul>		
← Default (ideate): deerveu		
C = perfavolerer werking (ideob2/demedivetou/ PereProf/perfavolerer we Add Application Tour)		
Add Experiment (ROE)		
Add Trial		

#### **ParaProf: File Preferences Window**

	ParaProf Preferences	_ 🗆 ×
File		
Font SansSerif Bold Size	n,c,t 0,0,0 n,c,t 0,0,1 n,c,t 0,0,2	
Litalic 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
Window defaults	Settings	
Units Seconds 💌	<ul> <li>Show Path Title in Reverse</li> <li>Reverse Call Paths</li> <li>Interpret threads that do not call a given function as a 0 value for statistics computation</li> </ul>	
Show Values as Percent	Generate data for reverse calltree  (requires lots of memory) (does not apply to currently loaded profiles)  Show Source Locations  Auto label node/context/threads	
Restore Defaults	Apply	Cancel

#### **ParaProf: Group Changer Window**

TAU: ParaProf: Group Changer: profile.cubex - 💷							
Region		Current		Available			
filter:				new group			
!\$omp atomic @error.f:104 !\$omp atomic @error.f:51		CUBE_DEFAULT		CUBE_CALLPATH			
!\$omp do @error.f:33							
!\$omp do @error.f:91							
!\$omp do @exact_rhs.f:147			~,				
!\$omp do @exact_rhs.f:247							
!\$omp do @exact_rhs.f:31							
!\$omp do @exact_rhs.f:346							
!\$omp do @exact_rhs.f:46							
!\$omp do @initialize.f:100							
!\$omp do @initialize.f:119							
!\$omp do @initialize.f:137							
!\$omp do @initialize.f:156							
!\$omp do @initialize.f:174							
!\$omp do @initialize.f:192							
!\$omp do @initialize.f:31	-						
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#### **ParaProf: Derived Metric Panel in Manager Window**

Applications		MetricField	Value
Standard Applications		Nome	Time
		Application ID	0
		Experiment ID	0
		Trial ID	0
profile.cubex		Metric ID	0
			5
- PAPI FP INS	=		
— 🧿 ru utime			
— 🥥 ru_stime			
— 😉 ru_maxrss			
— 😉 ru_ixrss			
– 🥶 ru_idrss			
- • ru_isrss			
- Tu_inswap			
— 🥥 ru nsignals			
– 🥥 ru nycsw	-	<u></u>	
pression: "PAPLEP INS"/"Time"			Clea

### **Sorting Derived FLOPS metric by Exclusive Time**

TAU: ParaProf: node O, thread O - profile.cubex				
File Options Windows Help				
Metric: ( PAPI_FP_INS / Time ) Value: Exclusive Units: Derived metric shown in seconds format Sorted By: Exclusive (Time)				
3.0217E9 3.0217E9 3.2421E9 3.2421E9 3.0673E9 3.0673E9 3.0673E9	<pre>MAIN =&gt; adi_ =&gt; y_solve_ =&gt; !\$omp parallel @y_solve.f:43 =&gt; !\$omp do @y_solve.f:52 !\$omp do @y_solve.f:52 MAIN =&gt; adi_ =&gt; z_solve_ =&gt; !\$omp parallel @z_solve.f:43 =&gt; !\$omp do @z_solve.f:52 !\$omp do @z_solve.f:52 MAIN =&gt; adi_ =&gt; x_solve_ =&gt; !\$omp parallel @x_solve.f:46 =&gt; !\$omp do @x_solve.f:54 !\$omp do @x_solve.f:54</pre>			
3.3298E9 3.5138E9 3.514E9 1965740.083 2518815.107 2518981.066 3.502E8	<pre>MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:191 !\$omp do @rhs.f:80 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:80 !\$omp implicit barrier !\$omp parallel @rhs.f:28 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 !\$omp do @rhs.f:37</pre>			
3.4975E8 4.0207E9 4.0205E9 393146.074 393024.443 60.754 60.754	<pre>MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37 !\$omp do @rhs.f:301 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:301 !\$omp do @rhs.f:62 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:62 MAIN =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:62 MAIN =&gt; mpi_setup_ =&gt; MPI_Init_thread MPI_Init_thread</pre>			
2218222.902 2218222.902 2217983.431 2217983.431 2691052.918 2691052.918 2691052.918 1.5944E9 1.5944E9 65007.137	<pre>  MAIN_ =&gt; exch_qbc_ =&gt; copy_x_face_   copy_x_face_   MAIN_ =&gt; exch_qbc_ =&gt; copy_y_face_   copy_y_face_   MAIN_ =&gt; exch_qbc_   exch_qbc_ ] !\$omp do @rhs.f:384 ] MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:384   MAIN_ =&gt; exch_qbc_ =&gt; MPI_Waitall</pre>	T		

## **ParaProf:**

IAU: Paraprof: Statistics for: node 0, thread 0 - /p/home/jusers/shende	1/juwels/workshop/SC22/TeaLeaf_CUDA/bi	n		_ 🗆 ×	TAU: ParaProf: /p/home/jusers/shende1/juwels/workshop	/SC22/TeaLeaf_CUE TAU: ParaProf:	Function Data Window: /p/home/jusers/shende1/jowati:
ile Options Windows Help					File Options Windows Help		vs neip
Name	Exclusive TAUGPU TIME Inclusive		Calls	Child Calls	Metric: TAUGPU_TIME	Name:	anag salva and a nave(kannal infa t
TAIL application	0.003	47.092	1	1		double const*, do	uble*, double const*, double const*.
taunreload main	6 154	47.089	1	676 842	Std Day	double*, double	const*, double const*, double const*, double
cudaMemony	29 198	29 198	214 620	010,042	Mean	const*, double co	onst*, double const*, double const*, int)
MPI Waitall()	8.663	8.663	104.774		Max	Metric Name: TA	UGPU_TIME
MPI Init()	0.177	1.075	1	12	Min	Value: Exclusive	
cudaStreamCreateWithFlags	0.898	0.898	1		node 0, thread 0	Units: seconds	
cudaLaunchKernel [THROTTLED]	0.705	0.705	100,001	C	node 0, thread 1	_	
MPI_Allreduce()	0.131	0.551	4,752	23,760	node 1, thread 0		6.252 std. dev.
MPI Collective Sync	0.384	0.384	4,764		node 1, thread 1		6.252 mean
MPI_Testall()	0.238	0.238	52,387	c	node 2, inread 0	12.526	max
MPI_Finalize()	0.142	0.142	1	3	node 3 thread 0	12.466	min unde 0 (to 1)
MPI_Isend() [THROTTLED]	0.119	0.119	100,001	c	node 3, thread 1	12.484	node 0, thread 1
MPI_Irecv() [THROTTLED]	0.098	0.098	100,001	C	node 4, thread 0	12.310	node 2, thread 1
MPI_Cart_create()	0.073	0.073	1	c	node 4, thread 1	12.522	node 2, thread 1
MPI_Barrier()	0.039	0.039	7	C	node 5, thread 0	12.5	node 4, thread 1
cudaPointerGetAttributes	0.037	0.037	19,056	C	node 5, thread 1	12.499	node 5, thread 1
■ cudaMalloc	0.029	0.029	48	C	node 6, thread 0	12.526	node 6, thread 1
cudaGetDeviceProperties	0.003	0.003	1	c	node 6, thread 1	12.523	node 7, thread 1
cudaDeviceSynchronize	0.002	0.002	132	c	node 7, thread 0	_	
MPI_Reduce()	0	0.001	12	60	Abde 2. Urread		
cudaFree	0.001	0.001	8	c	TAU: ParaProf: 3D Visualizer: /p/home/jusers/shende1/ju	uwels/workshop/SC22/TeaLeaf_CUDA/bin	_ 🗆 ×
cudaMemset	0	0	38	C	File Options Windows Help		
cudaGetLastError	0	0	46	c			🖡 👝 Triangle Mesh
cudaStreamDestroy	0	0	1	C			P Pl-t
cudaSetDevice	0	0	4	C			Bar Plot
cudaGetDeviceCount	0	0	9	C			<ul> <li>Scatter Plot</li> </ul>
MPI_Info_delete()	0	0	1	c			Toolog Block
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