Performance Analysis of OpenSHMEM Applications with TAU Commander

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OpenSHMEM'17
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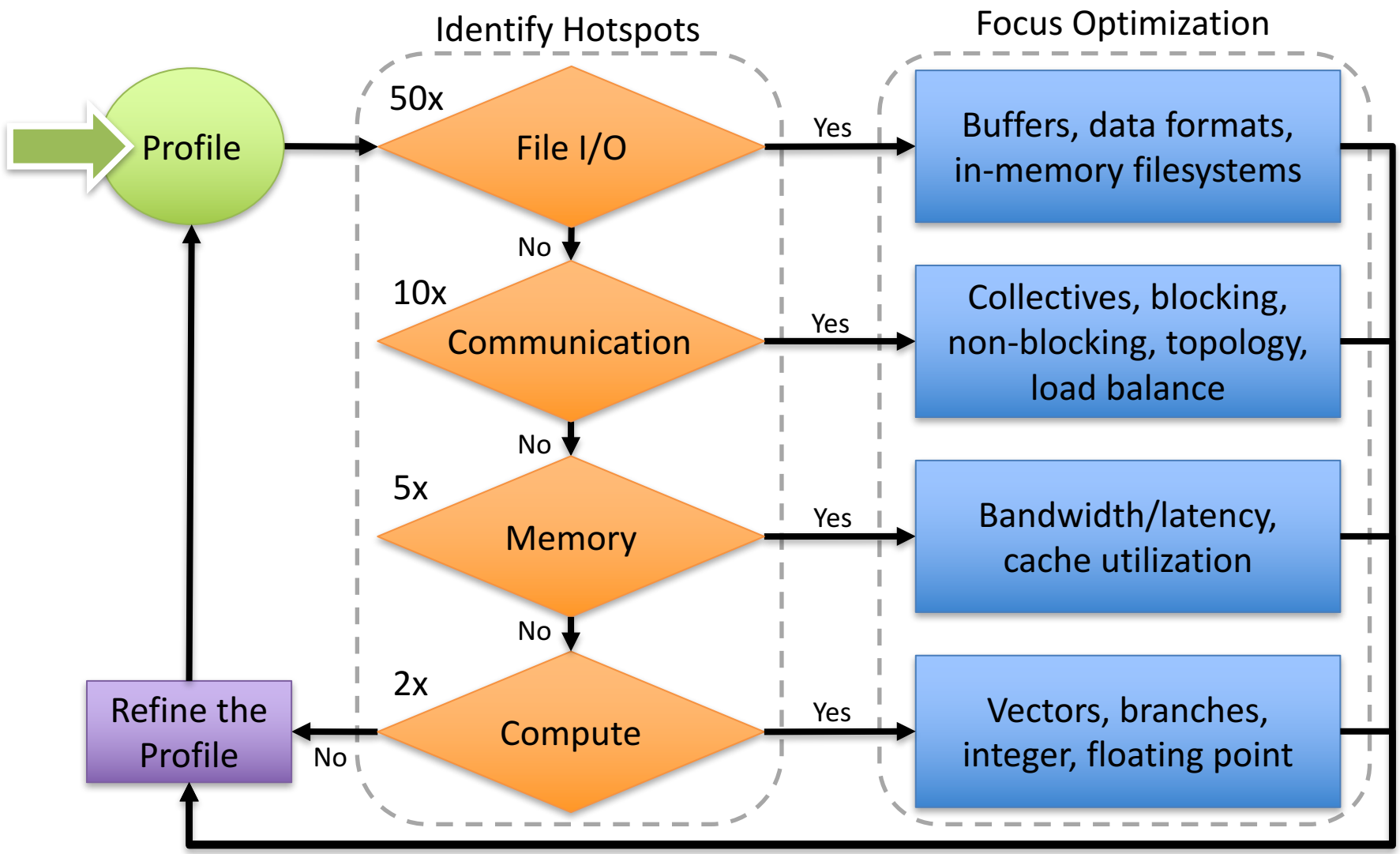
ParaTools

Identifying and Resolving Performance Issues



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Performance Tool Checklist

- **Universal tool or integrated toolkit**
- **Unbiased, accurate measurements**
  - File I/O: serial and parallel
  - Communication: inter- and intra-node
  - Memory: allocation and access
  - CPU: vectorization, cache utilization, etc.
- **Minimal overhead**
  - Provide multiple measurement methods
  - Focus on one performance aspect at a time
- **Easy to use**
  - Intuitive, systematic, and well documented
  - Easy to understand and configure

TAU Performance System®

TAU Commander

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THE TAU PERFORMANCE SYSTEM®

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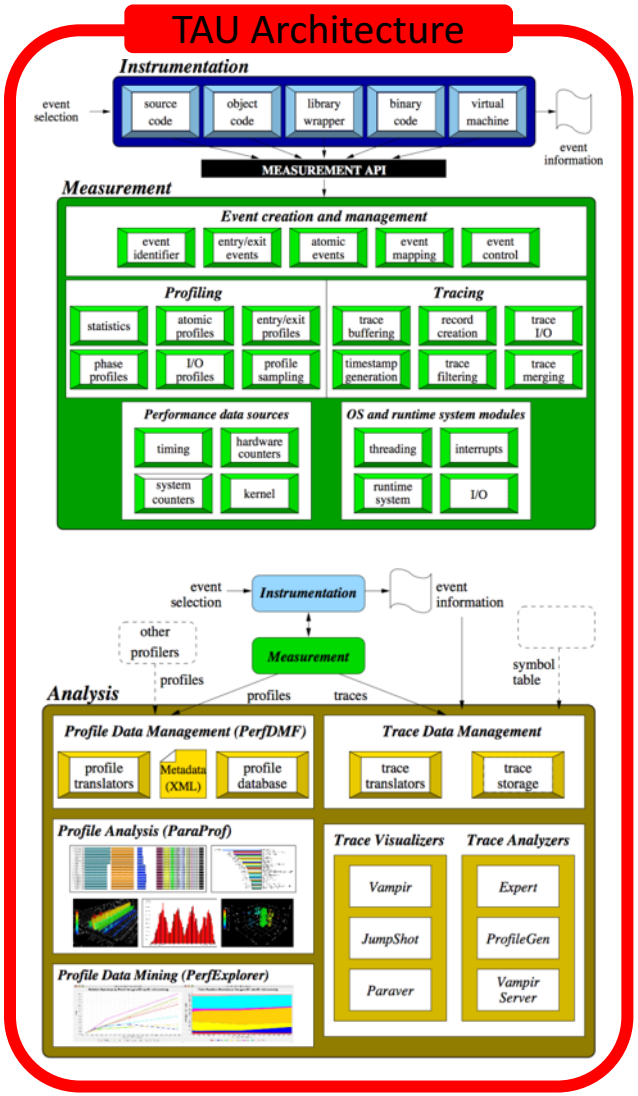
The TAU Performance System®

- ~25 year project
- *Integrated toolkit* for performance problem solving
  - Instrumentation, measurement, analysis, visualization
  - Portable profiling and tracing
  - Performance data management and data mining
- Direct and indirect measurement
- *Free, open source, BSD license*
- Available on all HPC platforms (and some non-HPC)
- http://tau.uoregon.edu/



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Questions TAU Can Answer

- **How much time** is spent in each application routine and outer *loops*? Within loops, what is the contribution of each *statement*?
- **How many instructions** are executed in these code regions? Floating point, Level 1 and 2 *data cache misses*, hits, branches taken, *vector instructions*?
- What is the **memory usage** of the code? When and where is memory allocated/de-allocated? Are there any *memory leaks*?
- 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 **time spent waiting for collectives**?
- How does the application **scale**?

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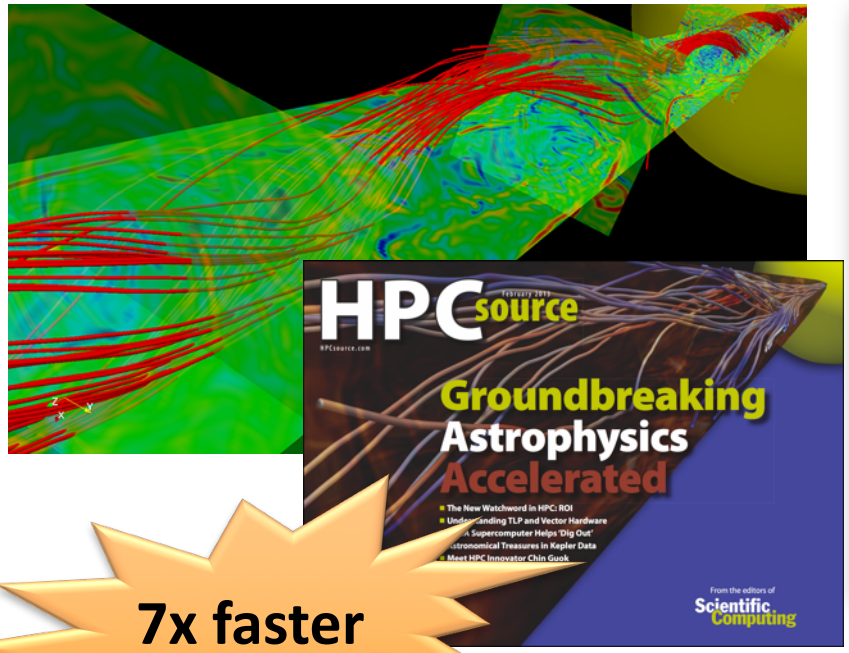
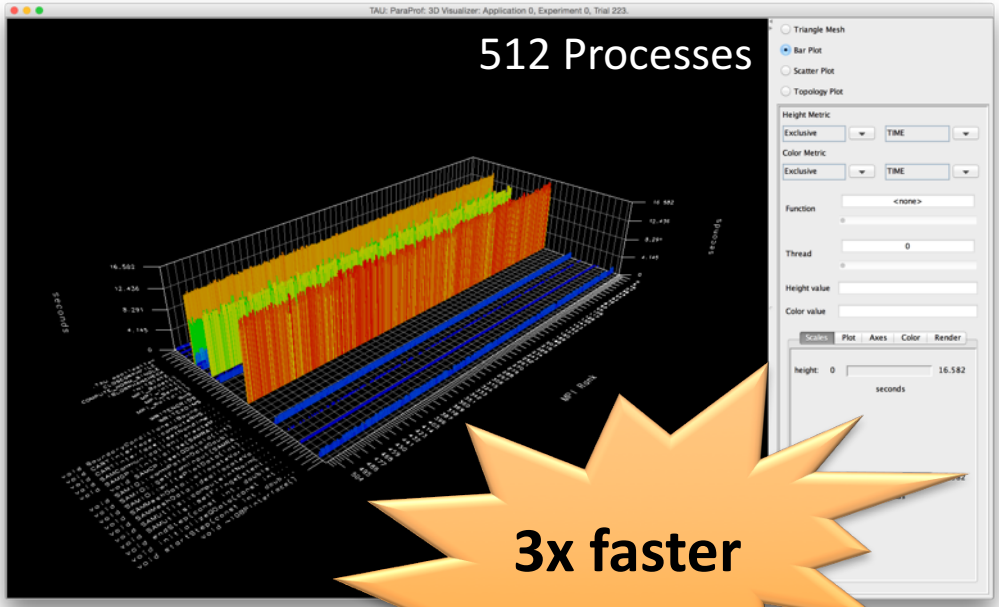
TAU at NASA, DOD, DOE, Industry

"These days I get excited about 1-2% speedups that I find....quite unusual to find something of this magnitude these days, especially with just a 2-line fix in the code! :)"



7x faster



3x faster

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A Tool for Experts

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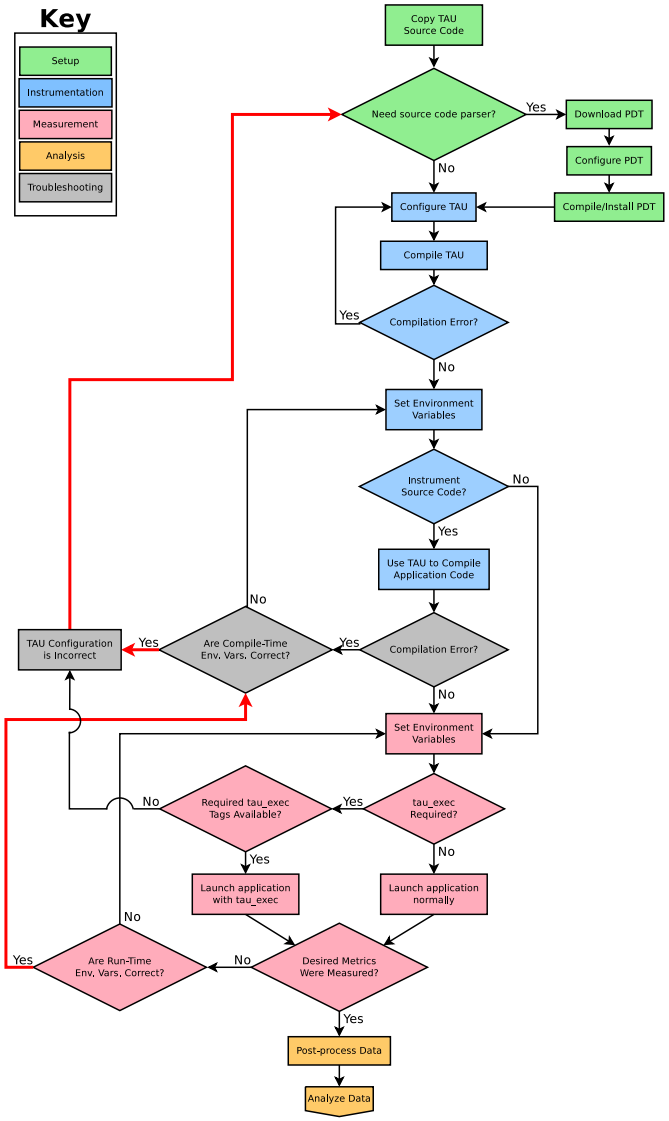
TAU Performance System® Workflow



- ParaTools/DOE study of 124 performance analysis workflows.
- Identified “pain points” in TAU usage.
- Developed a model for performance analysis workflows.
- Implemented in TAU Commander.

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TAU COMMANDER

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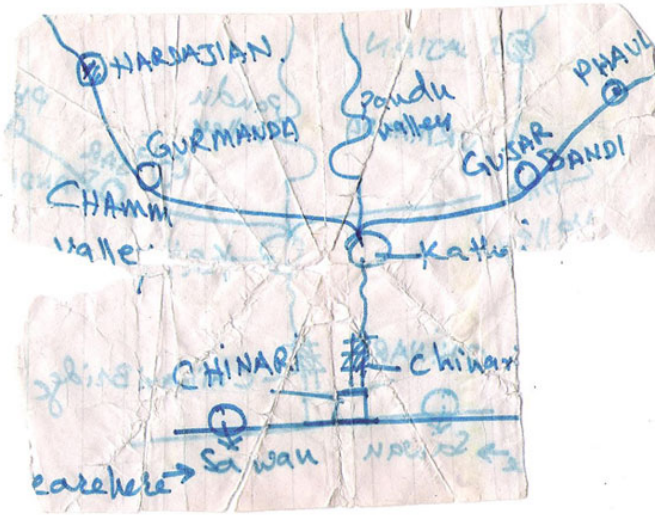
The TAU Commander Approach

- 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.

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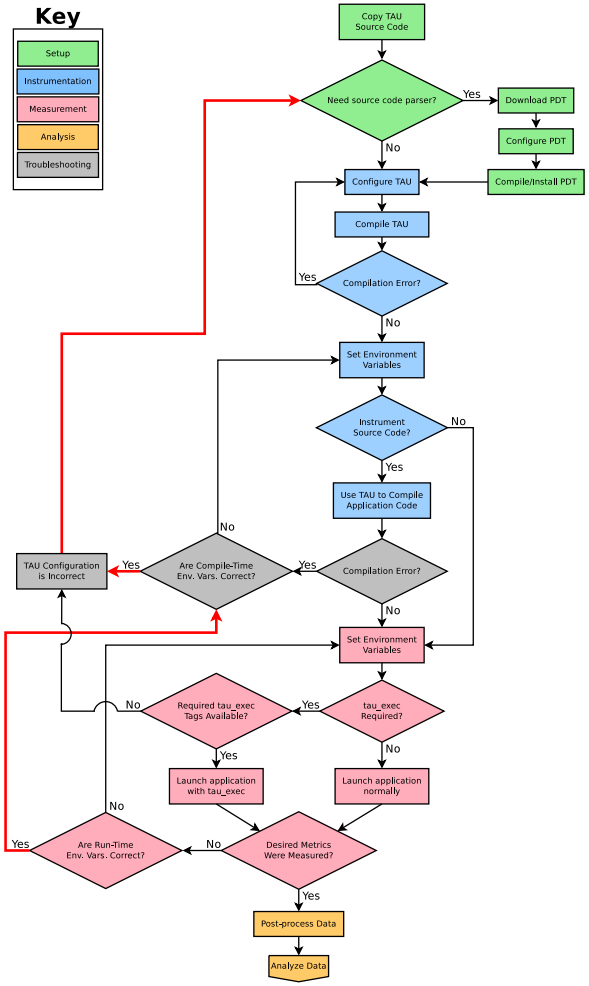
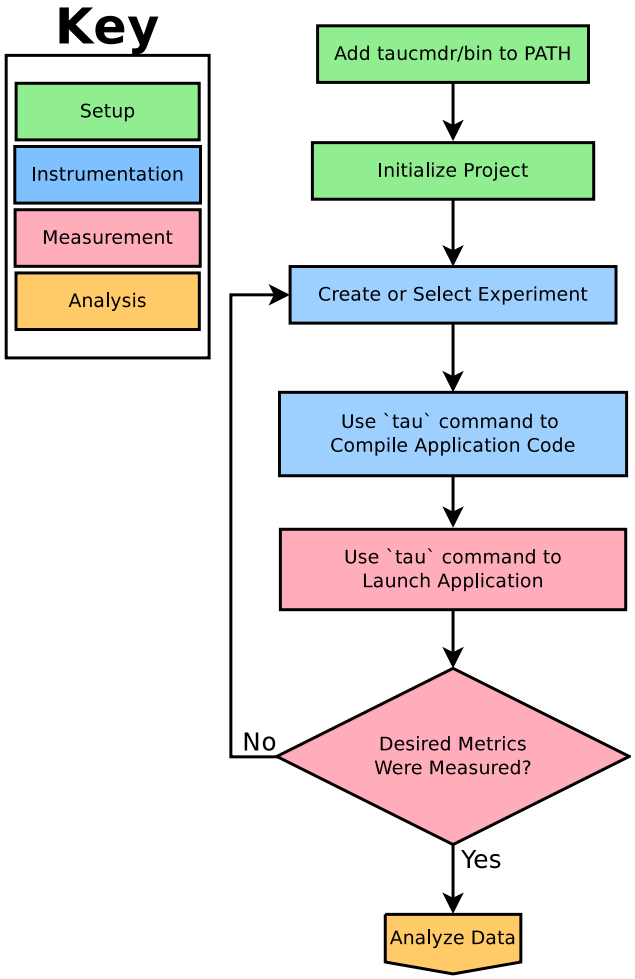
TAU Commander Simplifies the Workflow

TAU Performance System®



TAU Commander



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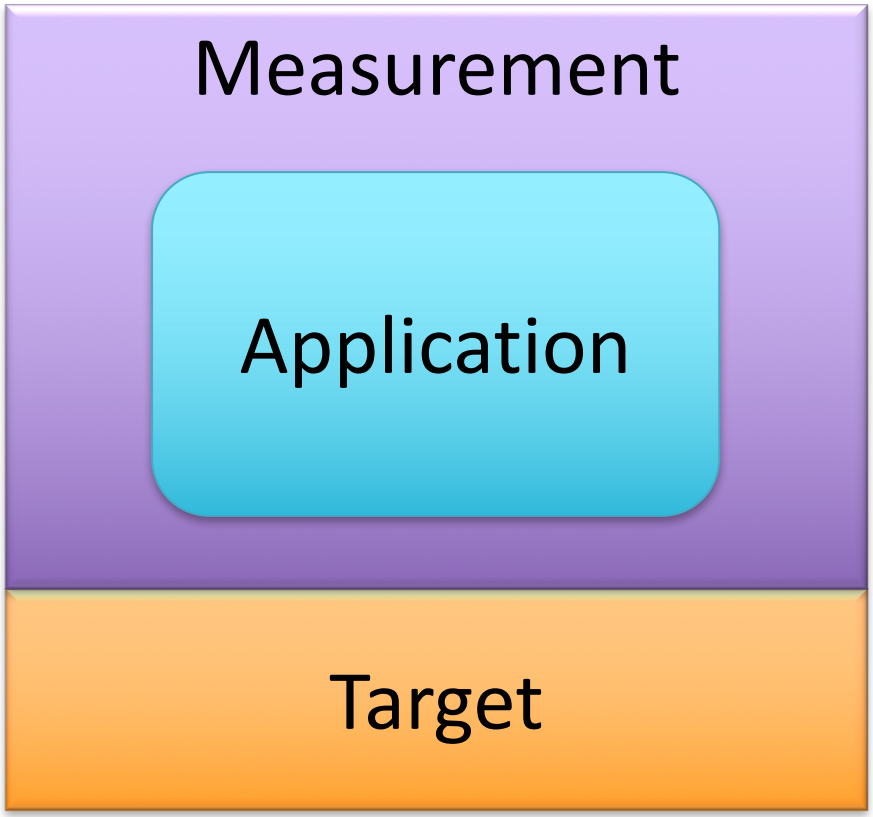
T-A-M Model for Performance Engineering

- Target
  - Installed software
  - Available compilers
  - Host architecture/OS
- Application
  - MPI, OpenMP, CUDA, OpenACC, etc.
- Measurement
  - Profile, trace, or both
  - Sample, source inst...



Experiment =
(Target, Application, Measurement)

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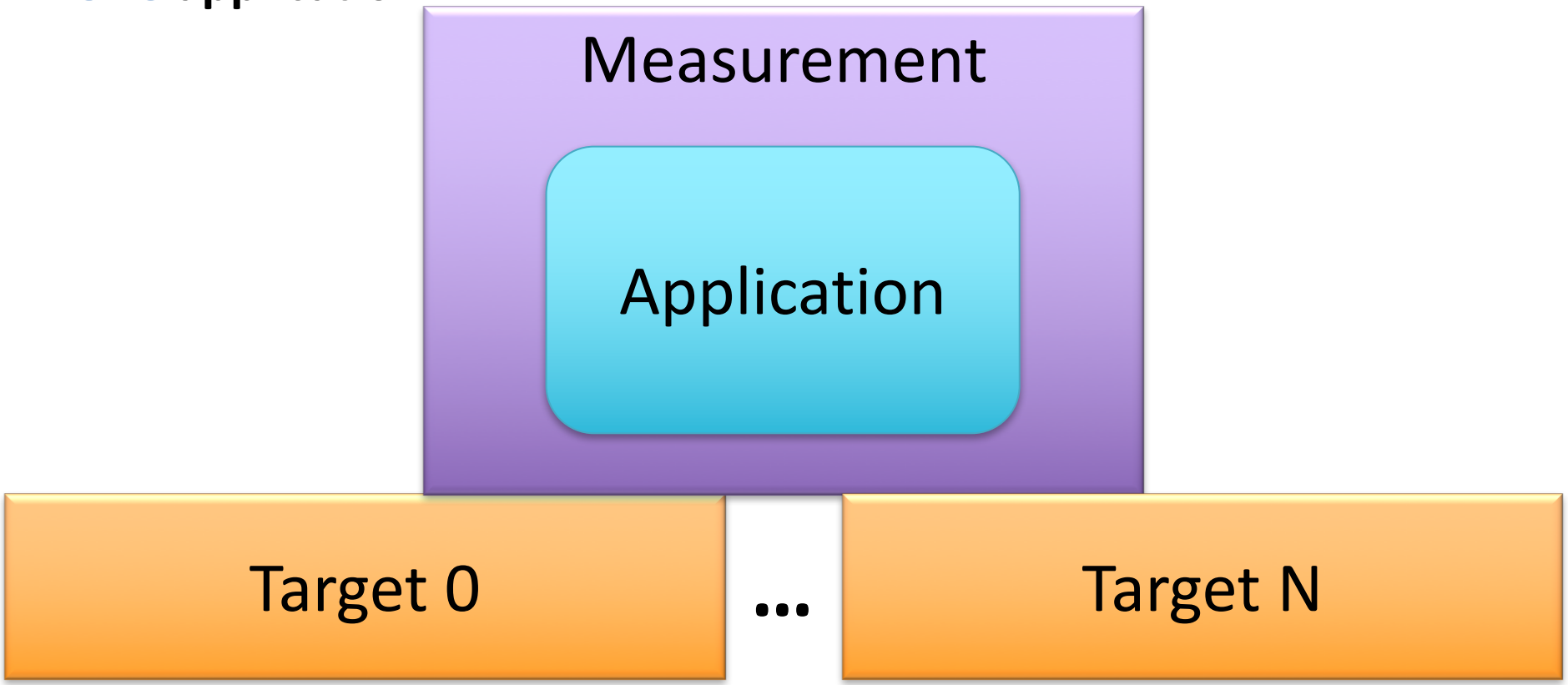
Which platform is best for my application?

- Many targets
  - Possibly same hardware, different software
- One measurement
- One application



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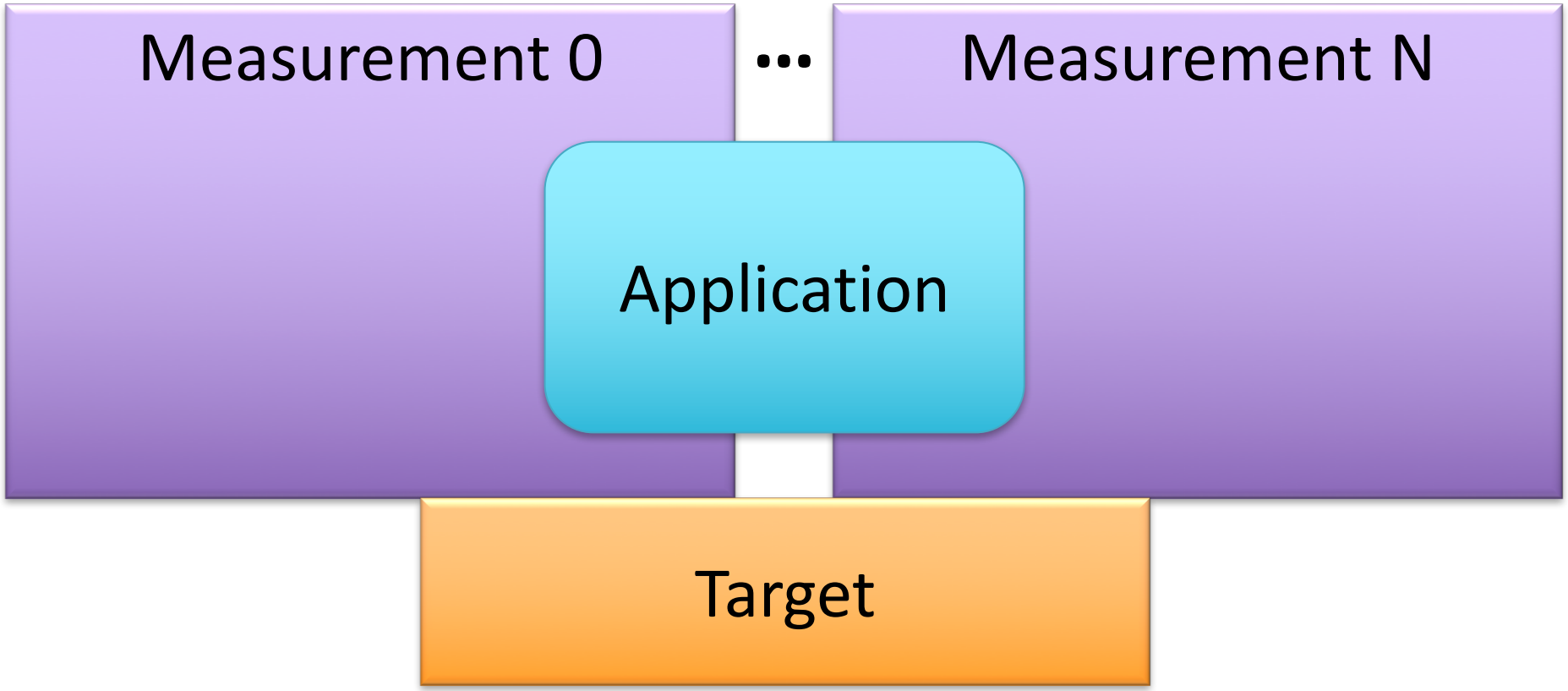
What are the performance characteristics of my application?

- One target
- Many measurements
- One application



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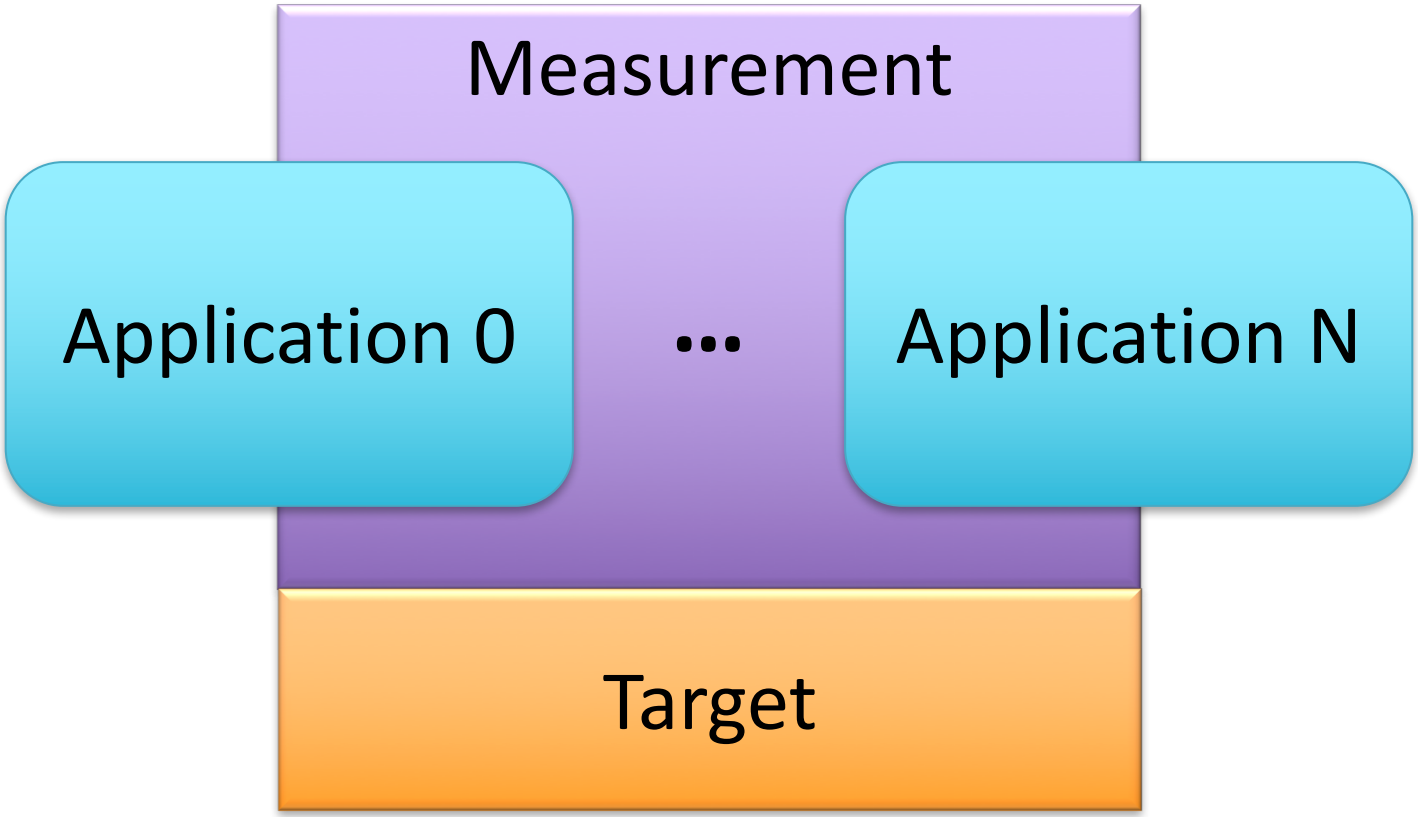
How well does my target perform various tasks?

- One target
- One measurement
- Many applications (e.g. benchmarks)



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Getting Started with TAU Commander

1. **tau** initialize
2. **tau** oshf90 *.f90 -o foo
3. **tau** oshrun -np 64 ./foo
4. **tau** show

Just put `**tau**` in front of everything and see what happens.

- 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.

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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 $
```


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TAU COMMANDER AND ISX

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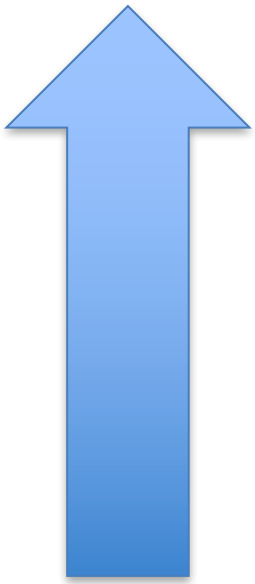
Step 1: Initialize TAU Project

```
$ cd ISx

$ tau initialize --shmem
```



- Creates a new project configuration using defaults
- Project files exist in a directory named ".tau"
- Like git, all directories below the directory containing the ".tau" directory can access the project
  - E.g. `tau dashboard` works in miniapp1/baseline

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Initializing ISx Project on Cori

ParaTools — ssh cori.nersc.gov — 120×50

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau initialize --shmem
[TAU] Cray C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Cray C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray MPI C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray MPI C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray MPI Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Cray SHMEM C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray SHMEM C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray SHMEM Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Created a new project named 'ISx'.
[TAU] Added application 'ISx' to project configuration 'ISx'.
[TAU] Added target 'cori09' to project configuration 'ISx'.
[TAU] Added measurement 'sample' to project configuration 'ISx'.
[TAU] Added measurement 'profile' to project configuration 'ISx'.
[TAU] Added measurement 'trace' to project configuration 'ISx'.
[TAU] Created a new experiment 'cori09-ISx-sample'
[TAU] Installing PDT to '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/pdt/77f947dd'
[TAU] Using PDT source archive '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz'
[TAU] Checking contents of '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz'
[TAU] Completed in 8.276 seconds
[TAU] Extracting '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz' to create
[TAU]     '/dev/shm/tmpQl6qTD/./pdtoolkit-3.24'
[TAU] Completed in 5.216 seconds
[TAU] Configuring PDT...
[TAU] Completed in 17.439 seconds
[TAU] Compiling PDT...
[TAU] Completed in 6.394 seconds
[TAU] Installing PDT...
[TAU] Completed in 0.115 seconds
[TAU] Checking installed files...
[TAU] Completed in 0.115 seconds
[TAU] Setting file permissions...
[TAU] Completed in 0.136 seconds
[TAU] Verifying PDT installation...
[TAU] Installing TAU Performance System at
[TAU]     '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/./tau-2.26.2'
[TAU] Configuring TAU...
[TAU] Completed in 26.358 seconds
[TAU] Compiling and installing TAU...
[TAU] 5.0 seconds [CPU: 32.4
```

Compiler detection

Project initialization

Download and install PDT

TAU installation progress

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TAU ISx Project Dashboard

ParaTools — ssh cori.nersc.gov — 120×50

```
== Project Configuration (/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/.tau/project.json) ==

+-------+---------+--------------+-----------------------+----------------+
| Name  | Targets | Applications |      Measurements     | # Experiments  |
+=======+=========+==============+=======================+================+
| ISx   | cori09  |     ISx      | sample, profile, trace |       1        |
+-------+---------+--------------+-----------------------+----------------+

== Targets in project 'ISx' ==================================================================================

+---------+---------+---------+---------------+---------------+---------------+
| Name    | Host OS | Host Arch | Host Compilers | MPI Compilers | SHMEM Compilers |
+=========+=========+=========+===============+===============+===============+
| cori09  | CNL     | x86_64  |     Cray      |     Cray      |     Cray      |
+---------+---------+---------+---------------+---------------+---------------+

== Applications in project 'ISx' ==============================================================================

+-------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
| Name  | Linkage | OpenMP  | Pthreads | TBB     | MPI     | CUDA    | OpenCL  | SHMEM   | MPC     |
+=======+=========+=========+=========+=========+=========+=========+=========+=========+=========+
| ISx   | static  | No      | No      | No      | No      | No      | No      | Yes     | No      |
+-------+---------+---------+---------+---------+---------+---------+---------+---------+---------+

== Measurements in project 'ISx' ==============================================================================

+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
| Name    | Profile | Trace   | Sample  | Source Inst. | Compiler Inst. | OpenMP  | CUDA    | I/O     | MPI     | SHMEM   |
+=========+=========+=========+=========+=========+=========+=========+=========+=========+=========+=========+
| sample  | tau     | none    | Yes     | never   | never   | ignore  | No      | No      | No      | Yes     |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
| profile | tau     | none    | No      | automatic | never   | ignore  | No      | No      | No      | Yes     |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
| trace   | none    | slog2   | No      | automatic | never   | ignore  | No      | No      | No      | Yes     |
+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+

== Experiments in project 'ISx' ===============================================================================

+---------------+---------+---------+---------+---------+---------+---------+
| Name          | Trials  | Data Size | Target  | Application | Measurement | TAU Makefile |
+===============+=========+=========+=========+=========+=========+=========+
| cori09-ISx-   | 0       | 0.0B    | cori09  | ISx     | sample  | Makefile.tau- |
| sample        |         |         |         |         |         | intel-        |
|               |         |         |         |         |         | 3f5a233a-     |
|               |         |         |         |         |         | shmem-pdt     |
+---------------+---------+---------+---------+---------+---------+---------+

Selected Experiment: cori09-ISx-sample
```


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Step 2: Use `tau` to compile

ParaTools — ssh cori.nersc.gov — 120×50

```
CC = tau cc
LD = $(CC)
DEBUGFLAGS = -g -p -O0 -DDEBUG
OPTFLAGS = -O3 -DNDEBUG -xCORE-AVX2
CFLAGS += -Wall -Wextra -std=c99 #$(OPTFLAGS)
LDLIBS += -lrt -lm
LDFLAGS +=
```

Prepend `tau` command to compiler command

Compile as normal

ParaTools — ssh cori.nersc.gov — 120×44

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx/SHMEM $ make optimized
tau cc -Wall -Wextra -std=c99  -O3 -DNDEBUG -xCORE-AVX2 -D SCALING_OPTION=1 -c pcg_basic.c -o obj/pcg_basic.o_s
[TAU] Cray SHMEM C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] TAU_MAKEFILE=/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/./tau-2.26.2/craycnl/lib/Makefile.tau-intel-3f5a233a-shmem-pdt
[TAU] TAU_OPTIONS=-optNoCompInst -optLinkOnly -optQuiet
[TAU] tau_cc.sh -g -Wall -Wextra -std=c99 -O3 -DNDEBUG -xCORE-AVX2 -D SCALING_OPTION=1 -c pcg_basic.c -o
[TAU]     obj/pcg_basic.o_s
```

- TAU Commander constructs a new compilation command line.
  - May replace compiler commands with TAU's compiler wrapper scripts.
  - May set environment variables, parse configuration files, etc.
  - If no changes are required then nothing is changed.

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Step 3: Use `tau` to run

jlinford — ssh cori.nersc.gov — 150×39

```
jlinford@nid00030 ~/workspace/openshmem17/applications/ISx/SHMEM $ tau srun -n 64 ./bin/isx.strong 134217728 output_strong
[TAU]
[TAU] == BEGIN Experiment at 2017-06-21 19:57:33.728778 ==========================================================
[TAU]
[TAU] PROFILEDIR=/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/.tau/ISx/cori09-ISx-sample/0
[TAU] SCOREP_ENABLE_TRACING=false
[TAU] TAU_CALLPATH=1
[TAU] TAU_CALLPATH_DEPTH=100
[TAU] TAU_CALLSITE=1
[TAU] TAU_COMM_MATRIX=0
[TAU] TAU_METRICS=TIME,
[TAU] TAU_PROFILE=1
[TAU] TAU_SAMPLING=1
[TAU] TAU_THROTTLE=1
[TAU] TAU_THROTTLE_NUMCALLS=100000
[TAU] TAU_THROTTLE_PERCALL=10
[TAU] TAU_TRACE=0
[TAU] TAU_TRACK_HEAP=0
[TAU] TAU_VERBOSE=0
[TAU] TRACEDIR=/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/.tau/ISx/cori09-ISx-sample/0
[TAU] srun -n 64 ./bin/isx.strong 134217728 output_strong
ISx v1.1
  Number of Keys per PE: 2097152
  Max Key Value: 268435456
  Bucket Width: 4194304
  Number of Iterations: 1
  Number of PEs: 64
  STRONG Scaling!
Average total time (per PE): 0.170602 seconds
Average all2all time (per PE): 0.023284 seconds
[TAU] Trial 0 produced 64 profile files.
[TAU]
[TAU] == END Experiment at 2017-06-21 19:57:38.794719 ====================
[TAU]
[TAU] Experiment: cori09-ISx-sample
[TAU] Current working directory: /global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM
[TAU] Data size: 1110404 bytes
[TAU] Command: srun -n 64 ./bin/isx.strong 134217728 output_strong
jlinford@nid00030 ~/workspace/openshmem17/applications/ISx/SHMEM $
```

Prepend `tau` command to command line

nt variables

Application executes, possibly with tau_exec

New data is added to the performance database

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Step 4: Use `tau` to view data

```
$ tau show
```

TAU: ParaProf: Mean Statistics - cori09-ISx-sample.trial0.ppk

Name	Exclusive TIME	Inclusive TIME ▽	Calls	Child Calls
.TAU application	0.306	1.347	1	326
void shmem_init(void) C	0.498	0.498	1	0
void shmem_finalize(void) C	0.462	0.462	1	0
[CONTEXT] .TAU application	0	0.32	6.406	0
[SUMMARY] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c}]	0.262	0.262	5.172	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {497}]	0.149	0.149	2.922	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {374}]	0.041	0.041	0.812	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {376}]	0.036	0.036	0.719	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {378}]	0.011	0.011	0.219	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {260}]	0.008	0.008	0.172	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {381}]	0.005	0.005	0.094	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {476}]	0.004	0.004	0.078	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {379}]	0.004	0.004	0.078	0
[SAMPLE] main [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/isx.c} {380}]	0.004	0.004	0.078	0
[SUMMARY] pcg32_boundedrand_r [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/pcg_basic.c}]	0.057	0.057	1.203	0
[SAMPLE] __close_nocancel [{/home/abuild/rpmbuild/BUILD/glibc-2.19/nptl/../sysdeps/unix/syscall-template.S} {81}]	0.001	0.001	0.016	0
[SAMPLE] __wrap_shmem_n_pes [{/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/SHMEM/bin/isx.strong} {0}]	0.001	0.001	0.016	0
void shmem_int_put(int *, const int *, size_t, int) C	0.037	0.037	126	0
long long shmem_longlong_fadd(long long *, long long, int) C	0.018	0.018	128	0
void *shmem_malloc(size_t) C	0.015	0.015	16	0
void shmem_barrier_all(void) C	0.009	0.009	27	0
void shmem_fcollect64(void *, const void *, size_t, int, int, int, long *) C	0.001	0.001	7	0
void shmem_collect32(void *, const void *, size_t, int, int, int, long *) C	0	0	1	0
void shmem_longlong_sum_to_all(long long *, const long long *, size_t, int, int, int, long long *, long *) C	0	0	1	0
int shmem_my_pe(void) C	0	0	9	0
void shmem_free(void *) C	0	0	8	0
int shmem_n_pes(void) C	0	0	1	0
[CALLSITE] void shmem_init(void) C	0.996	0.996	2	0
[CONTEXT] [CALLSITE] void shmem_init(void) C	0	0.481	1.688	0
[SAMPLE] __ioctl [{/home/abuild/rpmbuild/BUILD/glibc-2.19/misc/../sysdeps/unix/syscall-template.S} {81}]	0.473	0.473	1.344	0
[SAMPLE] _pmi_smp_barrier_join [{/usr/src/packages/BUILD/cray-pmi-5.0.10/src/pmi_core/smp_barrier.c} {70}]	0.006	0.006	0.281	0
[SAMPLE] Tau_lite_stop_timer [{/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/tau-2.26.2/src/Profile/TauCAPI.cpp} {	0.002	0.002	0.047	0
[SAMPLE] _dmappi_sheap_alloc [{/home/abuild/rpmbuild/BUILD/cray-dmapp-7.1.1/src/dmapp_sheap.c} {318}]	0.001	0.001	0.016	0

Note: ISx was sampled with callsites, OpenSHMEM measured directly via wrapper library

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OpenSHMEM'17

PERFORMANCE DATA ANALYSIS

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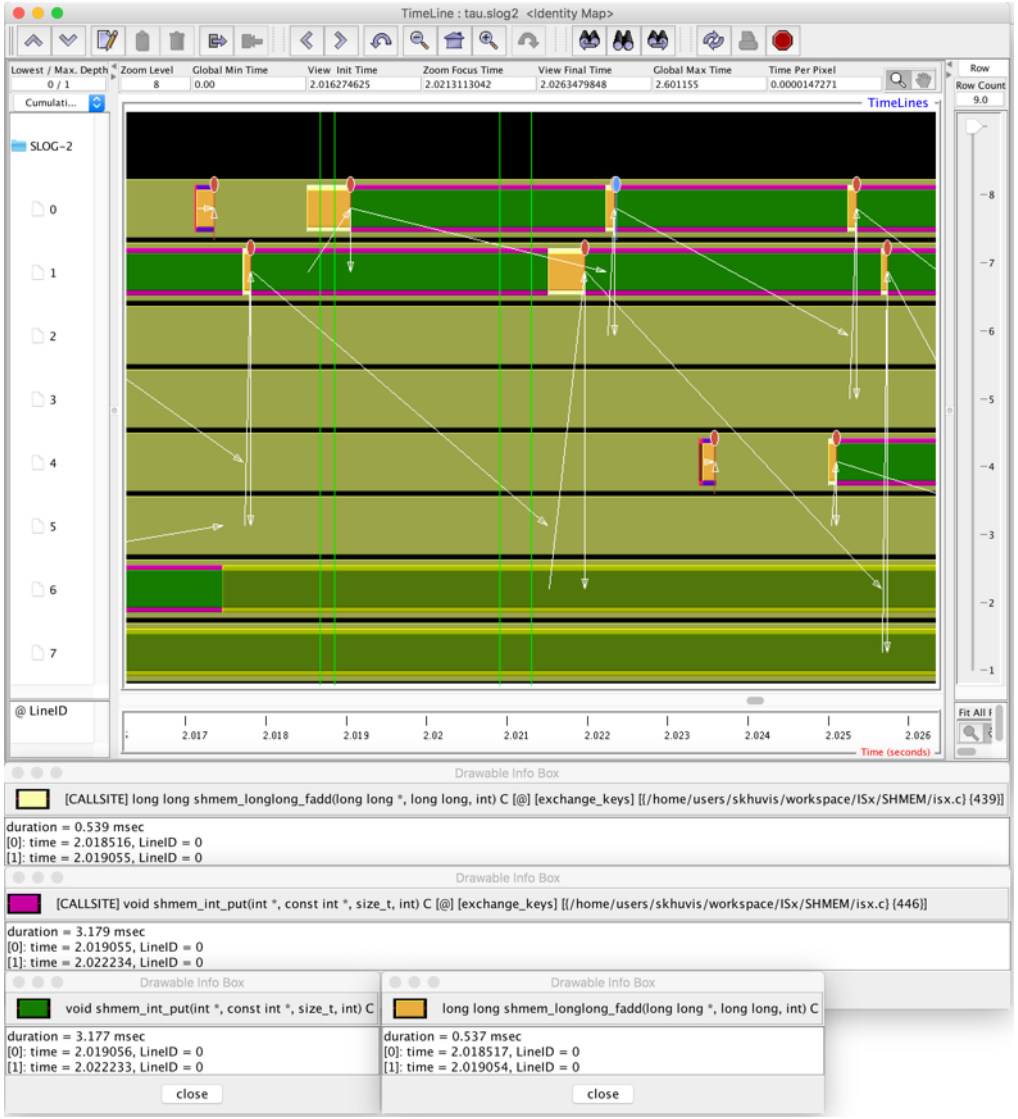
New: Callsites in Profiles and Traces



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Memory Allocation/Deallocation

TAU: ParaProf: Context Events for: node 0 - ISx.strong.titan.n256_N16.pdt.ppk

Name	Total	NumSamples	MaxValue	MeanValue	Std. Dev.
.TAU application					
Heap Memory Used (KB) at Entry	71.078	1	71.078	71.078	0
Heap Memory Used (KB) at Exit	2,095,745.812	1	2,095,745.812	2,095,745.812	0
Increase in Heap Memory (KB)	2,095,674.734	1	2,095,674.734	2,095,674.734	0.022
int main(const int, char **) C [{isx.c} {77,1}-{91,1}]					
Heap Memory Used (KB) at Entry	74.344	1	74.344	74.344	0
Heap Memory Used (KB) at Exit	2,095,743.594	1	2,095,743.594	2,095,743.594	0
Increase in Heap Memory (KB)	2,095,669.25	1	2,095,669.25	2,095,669.25	0.022
void log_times(char *) C [{isx.c} {583,1}-{615,1}]					
void init_shmem_sync_array(long *const restrict) C [{isx.c} {817,1					
int bucket_sort(void) C [{isx.c} {183,1}-{244,1}]					
char *parse_params(const int, char **) C [{isx.c} {96,1}-{174,1}]					
void shmem_init(void) C					
Heap Memory Used (KB) at Entry	78.5	1	78.5	78.5	0
Heap Memory Used (KB) at Exit	2,095,579.812	1	2,095,579.812	2,095,579.812	0
Increase in Heap Memory (KB)	2,095,501.312	1	2,095,501.312	2,095,501.312	0.022
void shmem_finalize(void) C					
Decrease in Heap Memory (KB)	8,386,709.938	3	4,193,279.984	2,795,569.979	1,976,659.551
Heap Memory Used (KB) at Entry	417,325,480,22...	201,120	2,096,798.172	2,075,007.36	300,712.116
Heap Memory Used (KB) at Exit	417,323,391,14...	201,120	2,096,798.172	2,074,996.973	300,892.442
Increase in Heap Memory (KB)	6,297,631.469	51	2,095,674.734	123,482.97	493,033.697
Message size received from all nodes	4,096	512	8	8	0
Message size sent to all nodes	2,093,136	1,022	4,416	2,048.078	2,046.067

% **`paraprof`** **(Right-click label [e.g "node 0"] → Show Context Event Window)**

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Message Statistics

TAU: ParaProf: Context Events for: node 0 - ISx.strong.titan.n256_N16.ppk

Name	Total	NumSam...	MaxValue	MinValue	MeanValue	Std. Dev.
.TAU application						
Message size received from all nodes	4,096	512	8	8	8	0
Message size received from node 0	16	2	8	8	8	0
Message size received from node 1	16	2	8	8	8	0
Message size received from node 10	16	2	8	8	8	0
Message size received from node 100	16	2	8	8	8	0
Message size received from node 101	16	2	8	8	8	0
Message size received from node 102	16	2	8	8	8	0
Message size received from node 103	16	2	8	8	8	0
Message size received from node 104	16	2	8	8	8	0
Message size received from node 105	16	2	8	8	8	0
Message size received from node 106	16	2	8	8	8	0
Message size received from node 107	16	2	8	8	8	0
Message size received from node 108	16	2	8	8	8	0
Message size received from node 109	16	2	8	8	8	0
Message size received from node 11	16	2	8	8	8	0
Message size received from node 110	16	2	8	8	8	0
Message size received from node 111	16	2	8	8	8	0
Message size received from node 112	16	2	8	8	8	0
Message size received from node 113	16	2	8	8	8	0
Message size received from node 114	16	2	8	8	8	0
Message size received from node 115	16	2	8	8	8	0
Message size received from node 116	16	2	8	8	8	0
Message size received from node 117	16	2	8	8	8	0
Message size received from node 118	16	2	8	8	8	0
Message size received from node 119	16	2	8	8	8	0
Message size received from node 12	16	2	8	8	8	0
Message size received from node 120	16	2	8	8	8	0
Message size received from node 121	16	2	8	8	8	0
Message size received from node 122	16	2	8	8	8	0
Message size received from node 123	16	2	8	8	8	0

% **`paraprof`** **(Right-click label [e.g "node 0"] → Show Context Event Window)**

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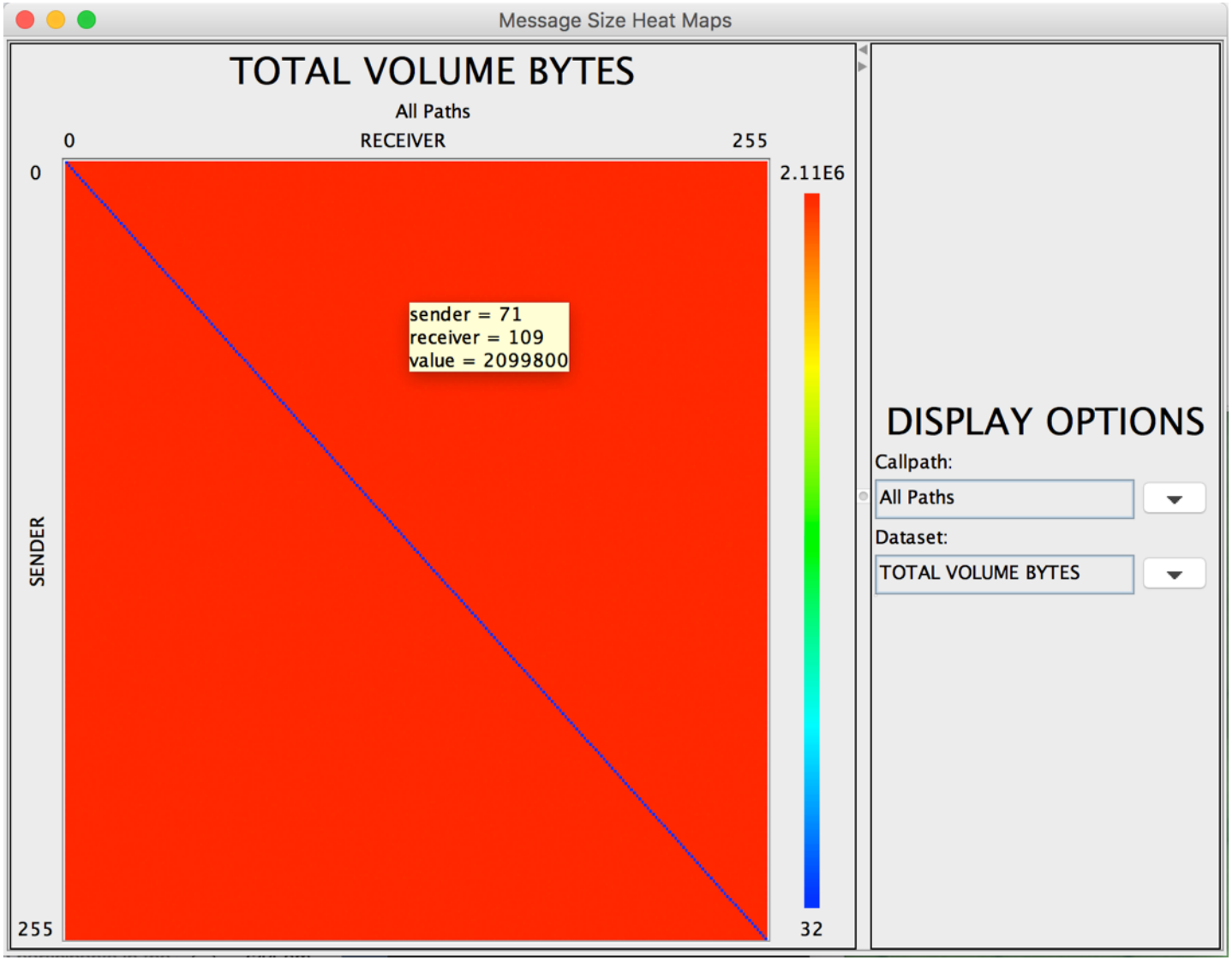
Communication Matrix



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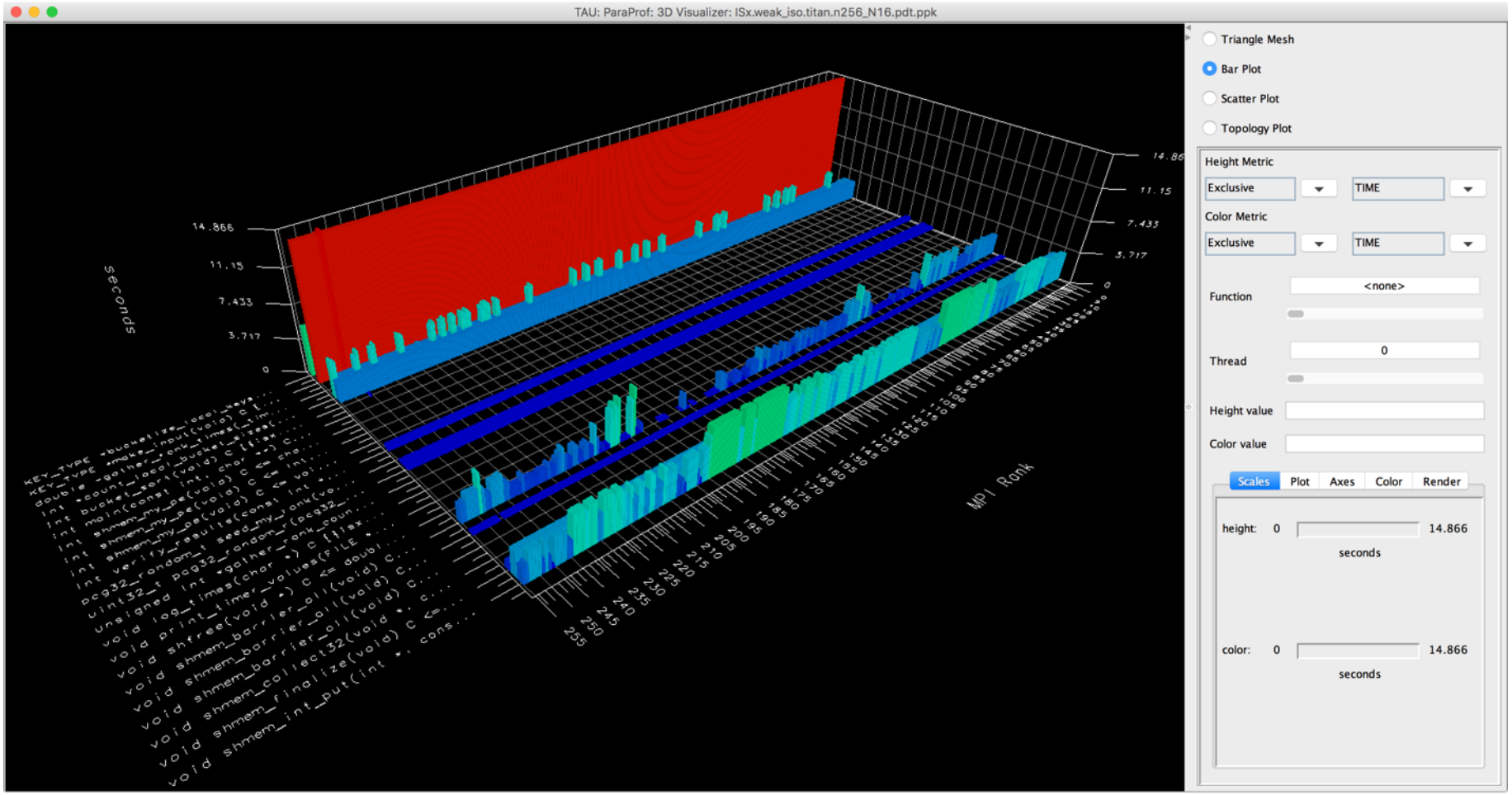
3D Profile Visualization



% paraprof (Windows → 3D Visualization)

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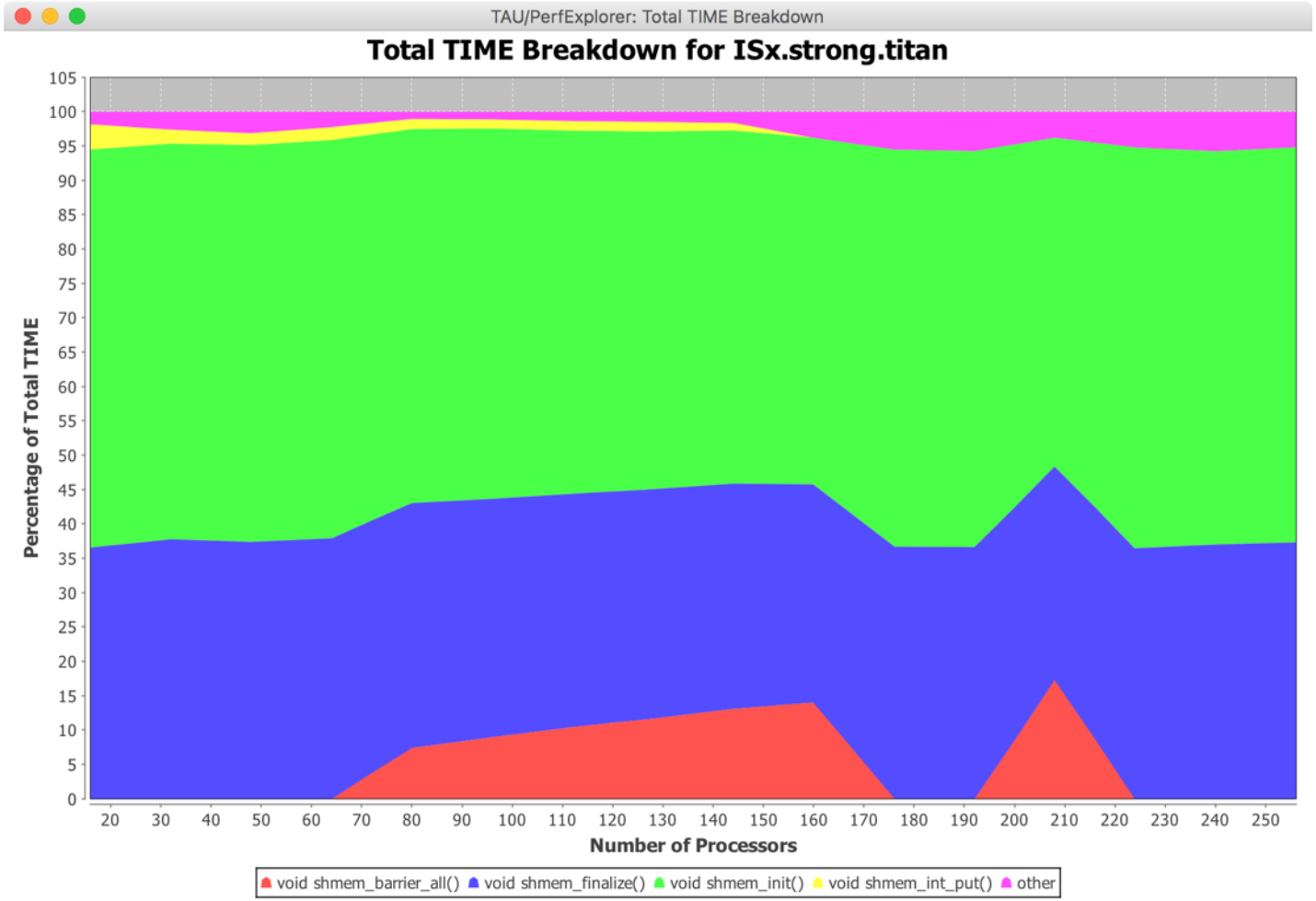
How Does Each Routine Scale?



`% perfexplorer` (Charts → Runtime Breakdown)

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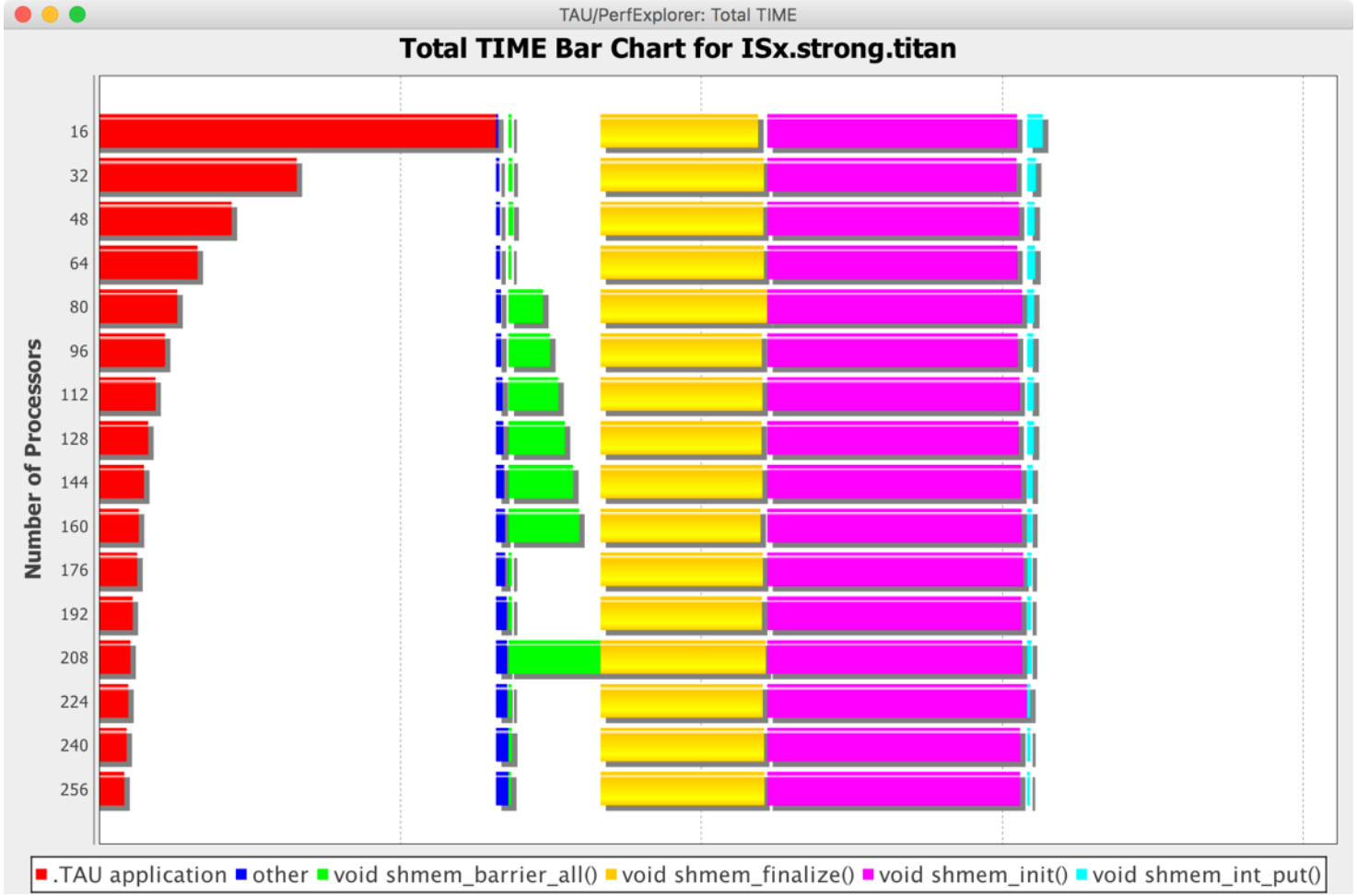
How Does Each Routine Scale?



`% perfexplorer` **(Charts → Stacked Bar Chart)**

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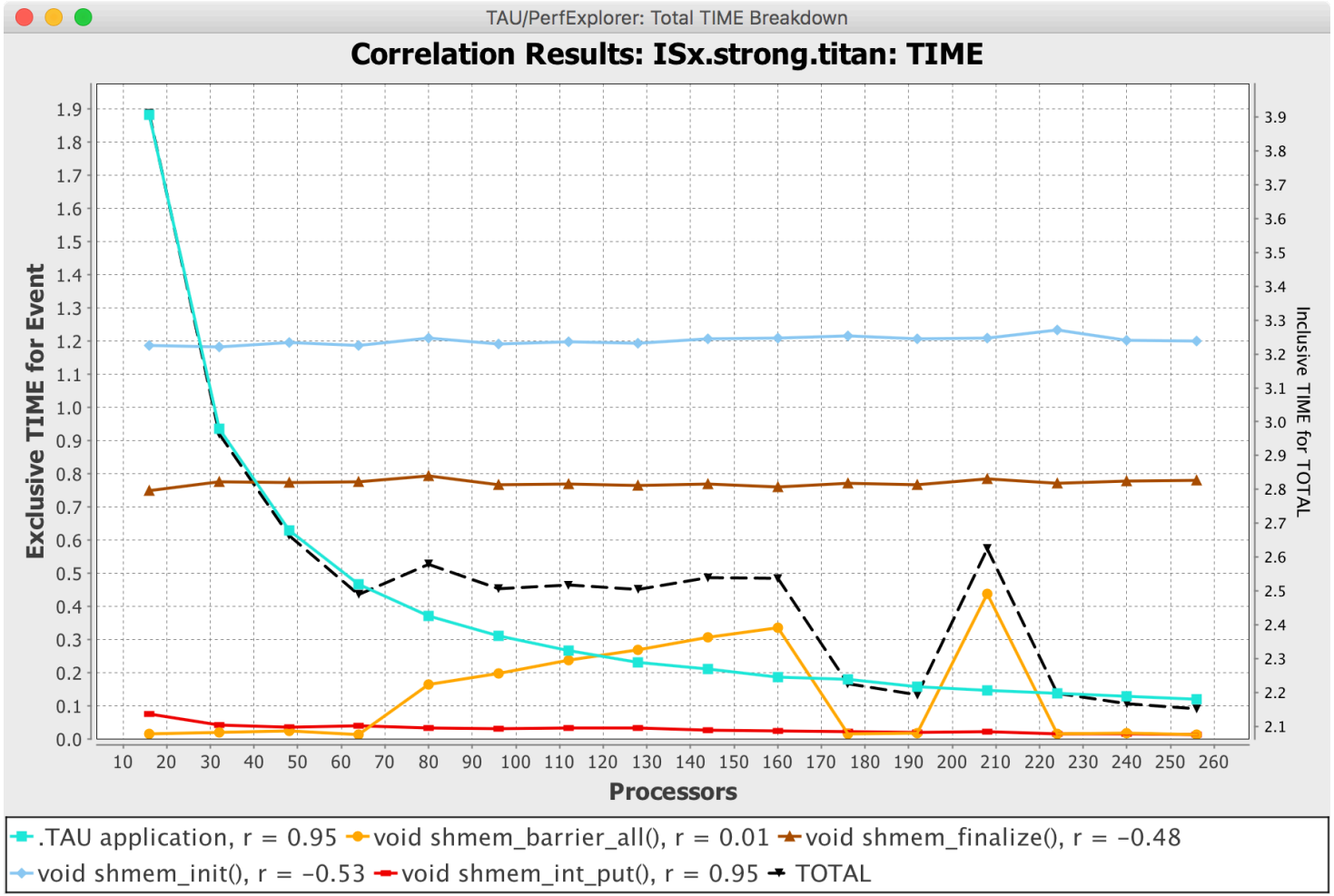
Which Events Correlate with Runtime?



% `perfexplorer` (Charts → Correlate Events with Total Runtime)

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OpenSHMEM'17

SOURCE-BASED INSTRUMENTATION

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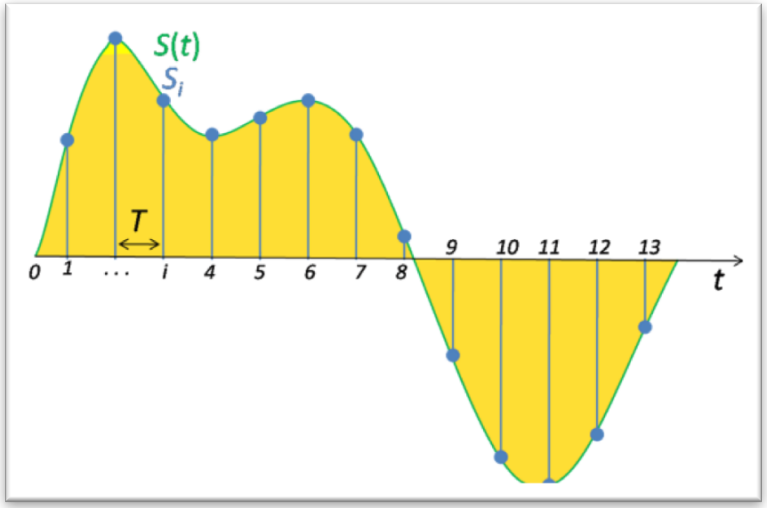
Source-based vs. Sampling

Direct via Probes

```
call TAU_START('potential')
// code
call TAU_STOP('potential')
```

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

Indirect via Sampling



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

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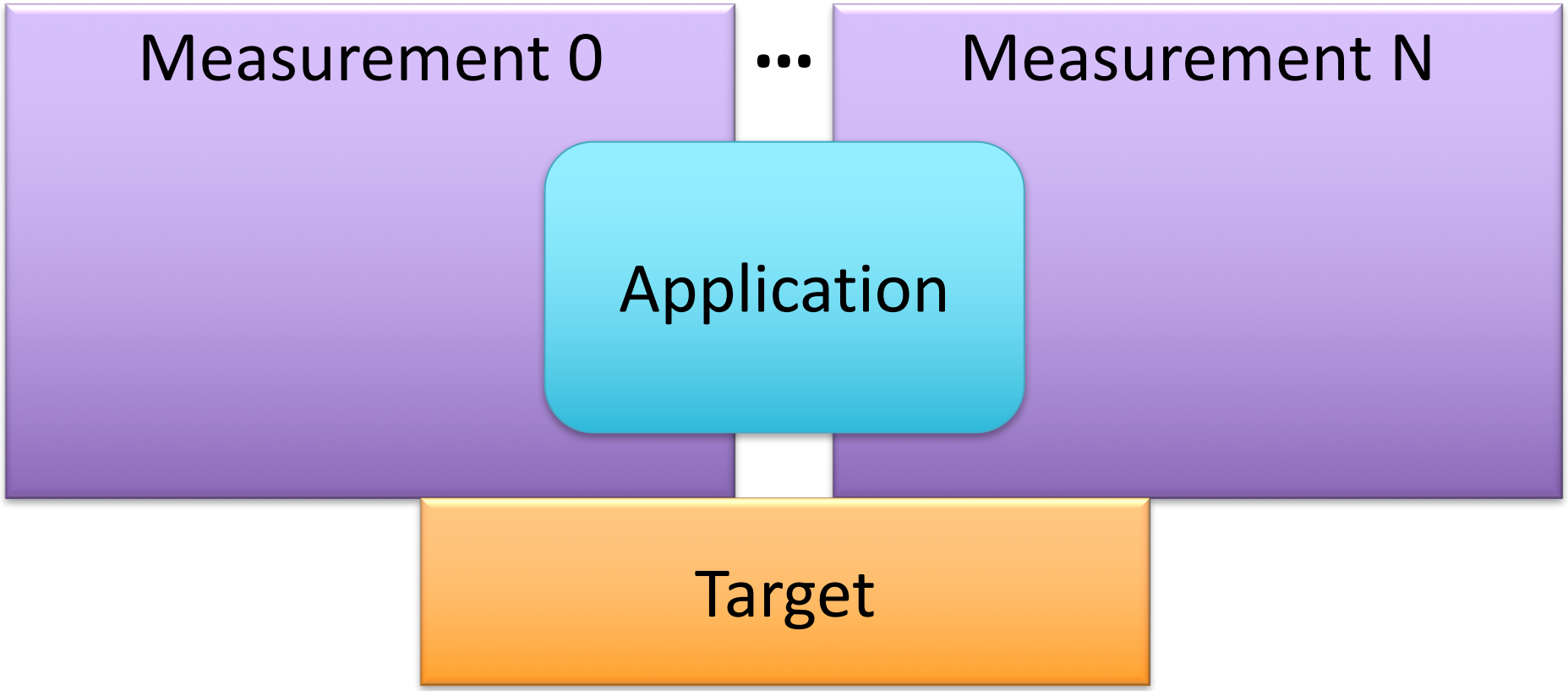
What are the performance characteristics of my application?

- One target
- Many measurements
- One application



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Create a New Experiment

Select a new measurement to create a new experiment

ParaTools — ssh cori.nersc.gov — 120×17

```
jlinford@nid00073 ~/workspace/openshmem17/applications/ISx/SHMEM $ tau select profile
[TAU] Created a new experiment 'cori09-ISx-profile'
[TAU] Installing TAU Performance System at
[TAU]     '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/./tau-2.26.2'
[TAU] Configuring TAU...
[TAU] Completed in 155.459 seconds
[TAU] Compiling and installing TAU...
[TAU] Completed in 48.596 seconds
[TAU] Checking installed files...
[TAU] Completed in 10.551 seconds
[TAU] Setting file permissions...
[TAU] Completed in 2.556 seconds
[TAU] Verifying TAU Performance System installation...
[TAU] Selected experiment 'cori09-ISx-profile'.
[TAU] Application rebuild required:
[TAU]   - source_inst changed from 'never' to 'automatic'
jlinford@nid00073 ~/workspace/openshmem17/applications/ISx/SHMEM $
```

TAU Performance System® automatically reconfigured and recompiled.

User advised that an application rebuild is required to use source-based instrumentation.

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Automatic TAU Configuration

- ./configure -tag=dea32fb3 -arch=craycnl -cc=icc -c++=icpc -fortran=intel -shmem -shmeminc=/opt/cray/pe/mpt/7.4.4/gni/sma/include -shmemlib=/opt/cray/pe/mpt/7.4.4/gni/sma/lib64 -shmemlibrary=-L/opt/cray/pe/libsci/16.09.1/INTEL/15.0/x86_64/lib#-L/opt/cray/dmapp/default/lib64#-L/opt/cray/pe/mpt/7.4.4/gni/mpich-intel/16.0/lib#-L/opt/cray/rca/2.1.6_g2c60fbf-2.265/lib64#-L/opt/cray/alps/6.3.4-2.21/lib64#-L/opt/cray/xpmem/2.1.1_gf9c9084-2.38/lib64#-L/opt/cray/dmapp/7.1.1-39.37/lib64#-L/opt/cray/pe/pmi/5.0.10-1.0000.11050.0.0.ari/lib64#-L/opt/cray/ugni/6.0.15-2.2/lib64#-L/opt/cray/udreg/2.3.2-7.54/lib64#-L/opt/cray/pe/atp/2.1.0/libApp#-L/opt/cray/wlm_detect/1.2.1-3.10/lib64#-lpthread#-lsma#-lpmi#-ldmapp#-lsci_intel_mpi#-lsci_intel#-lm#-ldl#-lmpich_intel#-lrt#-lugni#-lalpslli#-lwlm_detect#-lalpsutil#-lrca#-lxpmem#-ludreg#-lmpichcxx_intel#-lmpichf90_intel -pdt=/global/project/projectdirs/m88/jlinford/taucmdr-test/system/pdt/77f947dd -pdt_c++=icpc -useropt=-O2#-g

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Source-based Instrumentation Data

TAU: ParaProf: Mean - cori09-ISx-profile.trial0.ppk

Metric: TIME
Value: Exclusive
Units: seconds

0.505	void shmem_init(void) C
0.36	void shmem_finalize(void) C
0.186	KEY_TYPE *make_input(void) C [{isx.c} {251,1}-{280,1}]
0.157	int *count_local_keys(const KEY_TYPE *const restrict) C [{isx.c} {486,1}-{522,1}]
0.054	uint32_t pcg32_boundedrand_r(pcg32_random_t *, uint32_t) C [{pcg_basic.c} {79,1}-{109,1}] [THROTTLED]
0.05	KEY_TYPE *bucketize_local_keys(const KEY_TYPE *, int *const restrict) C [{isx.c} {367,1}-{401,1}]
0.043	int *count_local_bucket_sizes(const KEY_TYPE *const restrict) C [{isx.c} {287,1}-{318,1}]
0.033	uint32_t pcg32_random_r(pcg32_random_t *) C [{pcg_basic.c} {60,1}-{67,1}] [THROTTLED]
0.032	void shmem_int_put(int *, const int *, size_t, int) C
0.017	long long shmem_longlong_fadd(long long *, long long, int) C
0.015	void *shmem_malloc(size_t) C
0.008	void shmem_barrier_all(void) C
0.007	int verify_results(const int *const restrict, const KEY_TYPE *const restrict) C [{isx.c} {529,1}-{577,1}]
7.1E-4	void shmem_fcollect64(void *, const void *, size_t, int, int, int, long *) C
2.6E-4	void shmem_collect32(void *, const void *, size_t, int, int, int, long *) C
1.9E-4	void shmem_longlong_sum_to_all(long long *, const long long *, size_t, int, int, int, long long *, long *) C
1.9E-4	KEY_TYPE *exchange_keys(const int *const restrict, const int *const restrict, const KEY_TYPE *const restrict) C [{isx.c} {407,1}-{477,1}]
1.4E-4	void log_times(char *) C [{isx.c} {583,1}-{615,1}]
1.1E-4	double *gather_rank_times(_timer_t *const) C [{isx.c} {725,1}-{761,1}]
9.9E-5	int bucket_sort(void) C [{isx.c} {183,1}-{244,1}]
8.6E-5	int shmem_my_pe(void) C
8.1E-5	int main(const int, char **) C [{isx.c} {77,1}-{91,1}]
5.6E-5	void shmem_free(void *) C
3.3E-5	void init_shmem_sync_array(long *const restrict) C [{isx.c} {817,1}-{823,1}]
2.3E-5	char *parse_params(const int, char **) C [{isx.c} {96,1}-{174,1}]
1.9E-5	unsigned int *gather_rank_counts(_timer_t *const) C [{isx.c} {766,1}-{802,1}]
1.8E-5	int *compute_local_bucket_offsets(const int *const restrict, int **) C [{isx.c} {327,1}-{361,1}]
1.7E-5	pcg32_random_t seed_my_rank(void) C [{isx.c} {806,1}-{812,1}]
1.6E-5	.TAU application
1.5E-5	void pcg32_srandom_r(pcg32_random_t *, uint64_t, uint64_t) C [{pcg_basic.c} {42,1}-{49,1}]
8.0E-6	int file_exists(char *) C [{isx.c} {830,1}-{841,1}]
6.7E-6	int shmem_n_pes(void) C
3.4E-6	void print_timer_values(FILE *) C [{isx.c} {705,1}-{720,1}]
1.6E-7	void report_summary_stats(void) C [{isx.c} {620,1}-{640,1}]

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OpenSHMEM'17

TRACING OPENSHMEM WITH TAU COMMANDER

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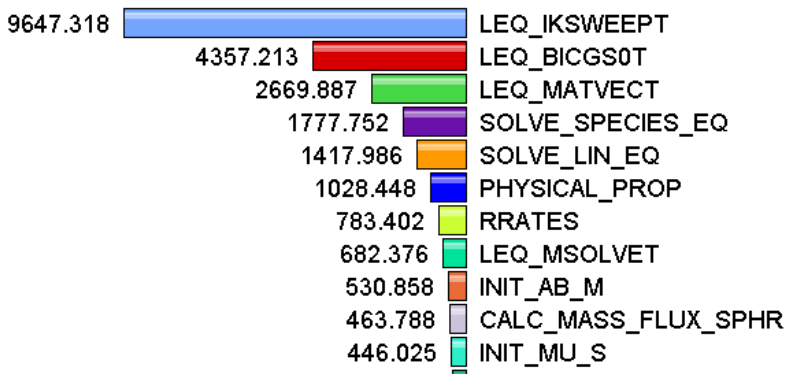
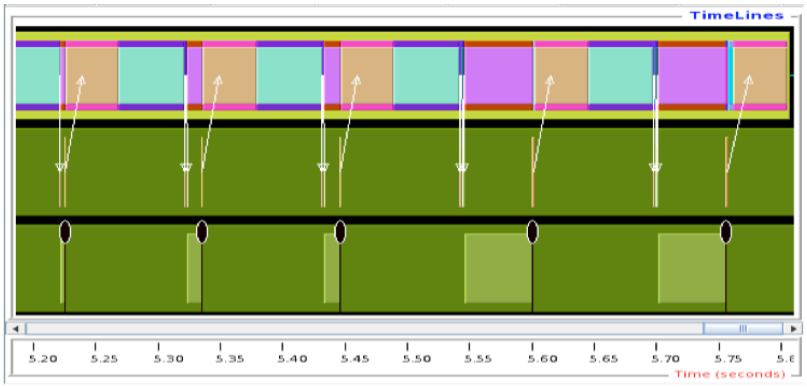
Measurement Approaches

Profiling



Shows **how much** time was spent in each routine

Tracing



Shows **when** events take place on a timeline

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New: OTF2 Now the Default Trace Format

jlinford — ssh cori.nersc.gov — 150×14

```
jlinford@nid00011 ~/workspace/ISx/SHMEM :( $ tau meas list
== Measurement Configurations (/global/project/projectdirs/m88/jlinford/ISx/SHMEM/.tau/project.json) ==========
```

Name	Profile	Trace	Sample	Source Inst.	Compiler Inst.	OpenMP	CUDA	I/O	MPI	SHMEM
sample	tau	none	Yes	never	never	ignore	No	No	No	Yes
profile	tau	none	No	automatic	never	ignore	No	No	No	Yes
trace	none	otf2	No	automatic	never	ignore	No	No	No	Yes

```
jlinford@nid00011 ~/wo ace/ISx/SHMEM $
```

- OTF2 dramatically improves on SLOG2:
  - Smaller trace files
  - Richer trace data, e.g. RMA events
  - Better trace visualization (Vampir, Ravel)
- TAU can now generate OTF2 files natively:
  - No Score-P required!

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TAU Commander with OpenSHMEM+OTF2

jlinford — ssh cori.nersc.gov — 150×39

```
jlinford@nid00011 ~/workspace/ISx/SHMEM $ tau srun -n 64 ./bin/isx.strong 134217728 output_strong
[TAU]
[TAU] == BEGIN Experiment at 2017-08-04 15:51:02.015260 ==========================================================================
[TAU]
[TAU] PROFILEDIR=/global/project/projectdirs/m88/jlinford/ISx/SHMEM/.tau/SHMEM/cori05-SHMEM-trace/0
[TAU] SCOREP_ENABLE_PROFILING=false
[TAU] SCOREP_EXPERIMENT_DIRECTORY=/global/project/projectdirs/m88/jlinford/ISx/SHMEM/.tau/SHMEM/cori05-SHMEM-trace/0
[TAU] TAU_CALLSITE=0
[TAU] TAU_COMM_MATRIX=0
[TAU] TAU_METRICS=TIME,
[TAU] TAU_PROFILE=0
[TAU] TAU_SAMPLING=0
[TAU] TAU_THROTTLE=1
[TAU] TAU_THROTTLE_NUMCALLS=100000
[TAU] TAU_THROTTLE_PERCALL=10
[TAU] TAU_TRACE=1
[TAU] TAU_TRACE_FORMAT=otf2
[TAU] TAU_TRACK_HEAP=0
[TAU] TAU_VERBOSE=0
[TAU] TRACEDIR=/global/project/projectdirs/m88/jlinford/ISx/SHMEM/.tau/SHMEM/cori05-SHMEM-trace/0
[TAU] srun -n 64 ./bin/isx.strong 134217728 output_strong
ISx v1.1
  Number of Keys per PE: 2097152
  Max Key Value: 268435456
  Bucket Width: 4194304
  Number of Iterations: 1
  Number of PEs: 64
  STRONG Scaling!
Average total time (per PE): 0.227839 seconds
Average all2all time (per PE): 0.020504 seconds
[TAU] Trial 0 produced 129 trace files.
[TAU]
[TAU] == END Experiment at 2017-08-04 15:51:07.847413 ============================================================================
[TAU]
[TAU] Experiment: cori05-SHMEM-trace
[TAU] Command: srun -n 64 ./bin/isx.strong 134217728 output_strong
[TAU] Current working directory: /
[TAU] Data size: 143.3MiB bytes
jlinford@nid00011 ~/workspace/ISx/
```

TAU_TRACE_FORMAT=otf2

OTF2 is 143MB vs. SLOG2 514MB

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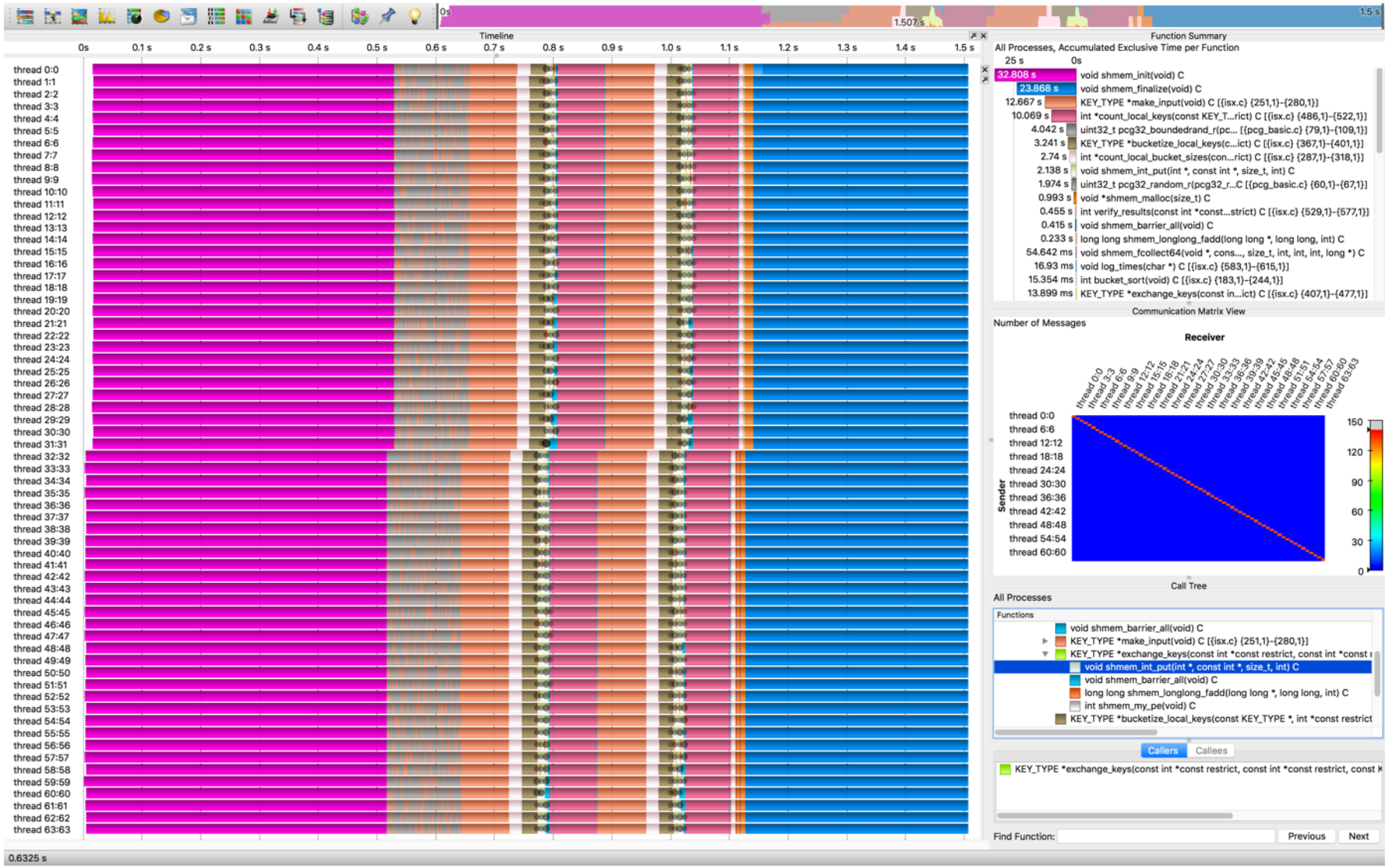
ISx in Vampir



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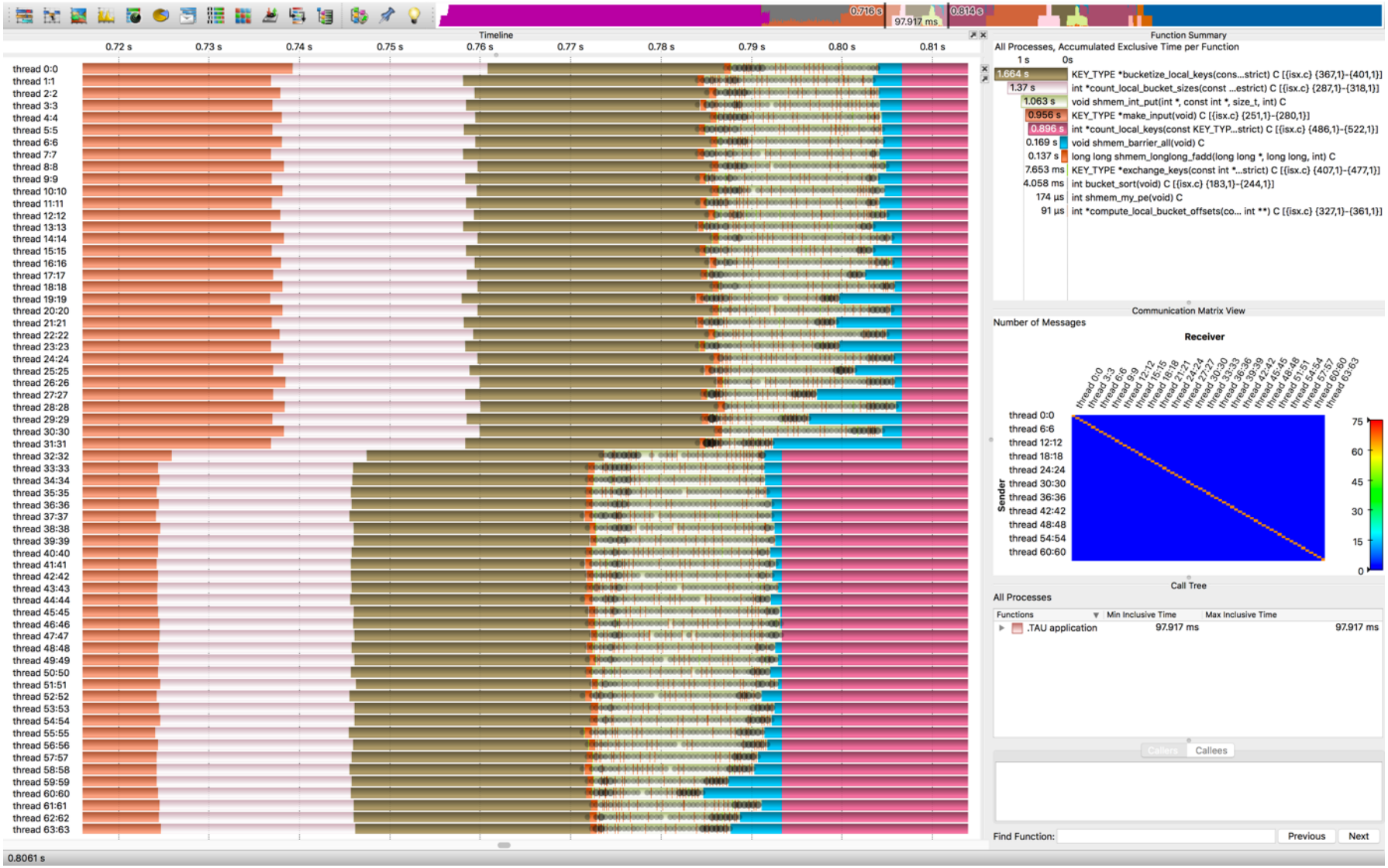
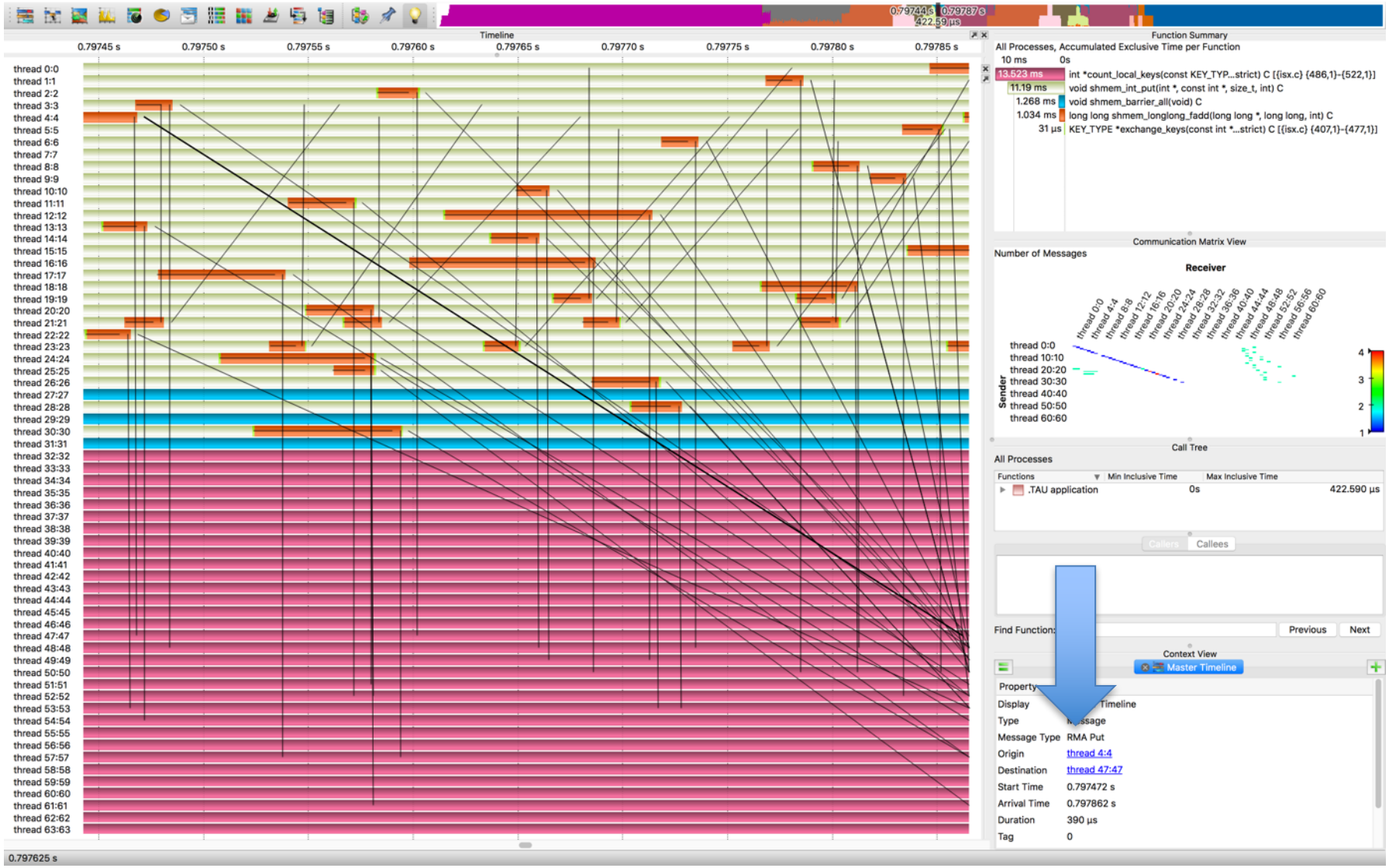
Different Nodes, Different Timelines



Get/Put Recorded as RMA Events



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TAU COMMANDER WITH SOS

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Create a New Target for SOS

Terminal — ssh cori.nersc.gov — 120×32

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau target create cori.SOS --shmem-compilers=OpenSHMEM
[TAU] Cray C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Cray C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray MPI C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray MPI C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray MPI Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Cray SHMEM C compiler '/opt/cray/pe/craype/2.5.7/bin/cc' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icc'
[TAU] Cray SHMEM C++ compiler '/opt/cray/pe/craype/2.5.7/bin/CC' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/icpc'
[TAU] Cray SHMEM Fortran compiler '/opt/cray/pe/craype/2.5.7/bin/ftn' wraps
[TAU]     '/opt/intel/compilers_and_libraries_2017.2.174/linux/bin/intel64/ifort'
[TAU] Added target 'cori.SOS' to project configuration 'ISx'.
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau target list
== Target Configurations (/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/.tau/project.json) ==

+----------+---------+----------+----------------+----------------+-----------------+
|   Name   | Host OS | Host Arch | Host Compilers | MPI Compilers | SHMEM Compilers |
+==========+=========+==========+================+================+=================+
|  cori09  |   CNL   |  x86_64  |      Cray      |      Cray      |       Cray      |
+----------+---------+----------+----------------+----------------+-----------------+
| cori.SOS |   CNL   |  x86_64  |      Cray      |      Cray      |    OpenSHMEM    |
+----------+---------+----------+----------------+----------------+-----------------+

jlinford@cori09 ~/workspace/openshmem17/applications/ISx $
```


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Select the SOS Target

Terminal — ssh cori.nersc.gov — 120×22

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau select cori.SOS ISx profile
[TAU] Created a new experiment 'cori.SOS-ISx-profile'
[TAU] Installing TAU Performance System at
[TAU]     '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/./tau-2.26.2'
[TAU] Configuring TAU...
[TAU] Completed in 26.045 seconds
[TAU] Compiling and installing TAU...
[TAU] Completed in 32.441 seconds
[TAU] Checking installed files...
[TAU] Completed in 1.974 seconds
[TAU] Setting file permissions...
[TAU] Completed in 1.337 seconds
[TAU] Verifying TAU Performance System installation...
[TAU] Selected experiment 'cori.SOS-ISx-profile'.
[TAU] Application rebuild required:
[TAU]   - SHMEM_CC changed from '/opt/cray/pe/craype/2.5.7/bin/cc' to
[TAU]     '/global/homes/j/jlinford/opt/sos-4f5f8192/bin/oshcc'
[TAU]   - SHMEM_CXX changed from '/opt/cray/pe/craype/2.5.7/bin/CC' to
[TAU]     '/global/homes/j/jlinford/opt/sos-4f5f8192/bin/oshc++'
[TAU]   - SHMEM_FC changed from '/opt/cray/pe/craype/2.5.7/bin/ftn' to
[TAU]     '/global/homes/j/jlinford/opt/sos-4f5f8192/bin/oshfort'
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $
```


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TAU COMMANDER AND KNL

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Create a new Target for KNL

Terminal — ssh cori.nersc.gov — 120×35

```
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau target copy cori09 cori.KNL --arch=KNL
[TAU] Added target 'cori.KNL' to project configuration 'ISx'.
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $ tau select cori.KNL ISx profile
[TAU] Created a new experiment 'cori.KNL-ISx-profile'
[TAU] Installing PDT to '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/pdt/04860562'
[TAU] Using PDT source archive '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz'
[TAU] Checking contents of '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz'
[TAU] Completed in 8.297 seconds
[TAU] Extracting '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/src/pdt.tgz' to create
[TAU]     '/dev/shm/tmpedFKyo/./pdtoolkit-3.24'
[TAU] Completed in 4.488 seconds
[TAU] Configuring PDT...
[TAU] Completed in 18.205 seconds
[TAU] Compiling PDT...
[TAU] Completed in 5.997 seconds
[TAU] Installing PDT...
[TAU] Completed in 0.116 seconds
[TAU] Checking installed files...
[TAU] Completed in 0.115 seconds
[TAU] Setting file permissions...
[TAU] Completed in 0.179 seconds
[TAU] Verifying PDT installation...
[TAU] Installing TAU Performance System at
[TAU]     '/global/project/projectdirs/m88/jlinford/taucmdr-test/system/tau/./tau-2.26.2'
[TAU] Configuring TAU...
[TAU] Completed in 18.261 seconds
[TAU] Compiling and installing TAU...
[TAU] Completed in 30.248 seconds
[TAU] Checking installed files...
[TAU] Completed in 0.215 seconds
[TAU] Setting file permissions...
[TAU] Completed in 0.484 seconds
[TAU] Verifying TAU Performance System installation...
[TAU] Selected experiment 'cori.KNL-ISx-profile'.
jlinford@cori09 ~/workspace/openshmem17/applications/ISx $
```


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KNL Performance Data

TAU: ParaProf: Mean - cori.KNL-ISx-profile.trial0.ppk

Metric: TIME
Value: Exclusive
Units: seconds

0.405	KEY_TYPE *make_input(void) C [{isx.c} {251,1}-{280,1}]
0.278	uint32_t pcg32_boundedrand_r(pcg32_random_t *, uint32_t) C [{pcg_basic.c} {79,1}-{109,1}] [THROTTLED]
0.275	int *count_local_keys(const KEY_TYPE *const restrict) C [{isx.c} {486,1}-{522,1}]
0.175	uint32_t pcg32_random_r(pcg32_random_t *) C [{pcg_basic.c} {60,1}-{67,1}] [THROTTLED]
0.109	void *shmem_malloc(size_t) C
0.101	KEY_TYPE *bucketize_local_keys(const KEY_TYPE *, int *const restrict) C [{isx.c} {367,1}-{401,1}]
0.095	void shmem_barrier_all(void) C
0.088	void shmem_int_put(int *, const int *, size_t, int) C
0.066	int *count_local_bucket_sizes(const KEY_TYPE *const restrict) C [{isx.c} {287,1}-{318,1}]
0.041	int bucket_sort(void) C [{isx.c} {183,1}-{244,1}]
0.04	int shmem_my_pe(void) C
0.03	char *parse_params(const int, char **) C [{isx.c} {96,1}-{174,1}]
0.026	int main(const int, char **) C [{isx.c} {77,1}-{91,1}]
0.024	long long shmem_longlong_fadd(long long *, long long, int) C
0.021	int verify_results(const int *const restrict, const KEY_TYPE *const restrict) C [{isx.c} {529,1}-{577,1}]
0.021	pcg32_random_t seed_my_rank(void) C [{isx.c} {806,1}-{812,1}]
0.02	void pcg32_srandom_r(pcg32_random_t *, uint64_t, uint64_t) C [{pcg_basic.c} {42,1}-{49,1}]
0.019	void init_shmem_sync_array(long *const restrict) C [{isx.c} {817,1}-{823,1}]
0.01	int shmem_n_pes(void) C
0.008	void shmem_longlong_sum_to_all(long long *, const long long *, size_t, int, int, int, long long *, long *) C
0.007	void shmem_fcollect64(void *, const void *, size_t, int, int, int, long *) C
0.006	KEY_TYPE *exchange_keys(const int *const restrict, const int *const restrict, const KEY_TYPE *const restrict) C [{isx.c} {407,1}-{477,1}]
0.004	int *compute_local_bucket_offsets(const int *const restrict, int **) C [{isx.c} {327,1}-{361,1}]
0.002	double *gather_rank_times(_timer_t *const) C [{isx.c} {725,1}-{761,1}]
0.001	unsigned int *gather_rank_counts(_timer_t *const) C [{isx.c} {766,1}-{802,1}]
0.001	void shmem_collect32(void *, const void *, size_t, int, int, int, long *) C
6.2E-4	void log_times(char *) C [{isx.c} {583,1}-{615,1}]
5.8E-4	void shmem_free(void *) C
3.7E-4	.TAU application
1.3E-5	void print_timer_values(FILE *) C [{isx.c} {705,1}-{720,1}]
1.2E-5	int file_exists(char *) C [{isx.c} {830,1}-{841,1}]
1.2E-6	void report_summary_stats(void) C [{isx.c} {620,1}-{640,1}]

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Final Dashboard

jlinford — ssh cori.nersc.gov — 140×65

```
[jlinford@cori12 ~/workspace/openshmem17/applications/ISx/SHMEM $ tau dashboard
== Project Configuration (/global/project/projectdirs/m88/jlinford/openshmem17/applications/ISx/.tau/project.json) ==================
| Name | Targets | Applications | Measurements | # Experiments |
| ISx | cori09, cori.SOS, cori.KNL | ISx | sample, profile, trace, comm | 6 |
== Targets in project 'ISx' ==========================================================================================
| Name | Host OS | Host Arch | Host Compilers | MPI Compilers | SHMEM Compilers |
| cori09 | CNL | x86_64 | Cray | Cray | Cray |
| cori.SOS | CNL | x86_64 | Cray | Cray | OpenSHMEM |
| cori.KNL | CNL | KNL | Cray | Cray | Cray |
== Applications in project 'ISx' ======================================================================================
| Name | Linkage | OpenMP | Pthreads | TBB | MPI | CUDA | OpenCL | SHMEM | MPC |
| ISx | static | No | No | No | No | No | No | Yes | No |
== Measurements in project 'ISx' ======================================================================================
| Name | Profile | Trace | Sample | Source Inst. | Compiler Inst. | OpenMP | CUDA | I/O | MPI | SHMEM |
| sample | tau | none | Yes | never | never | ignore | No | No | No | Yes |
| profile | tau | none | No | automatic | never | ignore | No | No | No | Yes |
| trace | none | slog2 | No | automatic | never | ignore | No | No | No | Yes |
| comm | tau | none | No | automatic | never | ignore | No | No | No | Yes |
== Experiments in project 'ISx' =======================================================================================
| Name | Trials | Data Size | Target | Application | Measurement | TAU Makefile |
| cori09-ISx-sample | 1 | 1.1MiB | cori09 | ISx | sample | Makefile.tau-intel-3f5a233a-shmem-pdt |
| cori09-ISx-profile | 1 | 1.4MiB | cori09 | ISx | profile | Makefile.tau-intel-dea32fb3-shmem-pdt |
| cori09-ISx-trace | 1 | 590.7MiB | cori09 | ISx | trace | Makefile.tau-intel-dea32fb3-shmem-pdt |
| cori.SOS-ISx-profile | 1 | 1.3MiB | cori.SOS | ISx | profile | Makefile.tau-intel-4b9b8c80-shmem-pdt |
| cori.SOS-ISx-comm | 1 | 7.9MiB | cori.SOS | ISx | comm | Makefile.tau-intel-4b9b8c80-shmem-pdt |
| cori.KNL-ISx-profile | 1 | 3.0MiB | cori.KNL | ISx | profile | Makefile.tau-intel-9ee2e236-shmem-pdt |
Selected Experiment: cori.KNL-ISx-profile
jlinford@cori12 ~/workspace/openshmem17/applications/ISx/SHMEM $
```


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CONCLUSION

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Download TAU Commander

www.taucommander.com

www.github.com/ParaToolsInc/taucmdr

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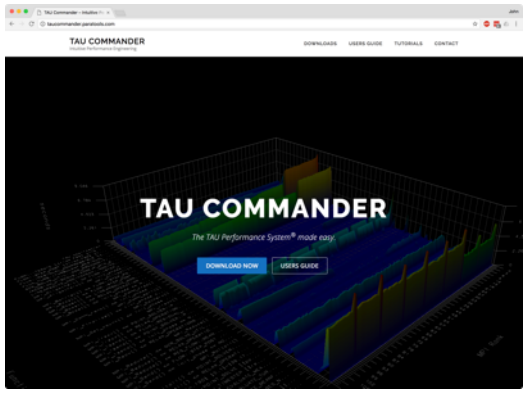

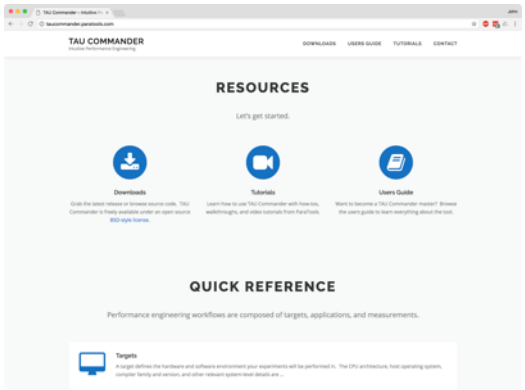

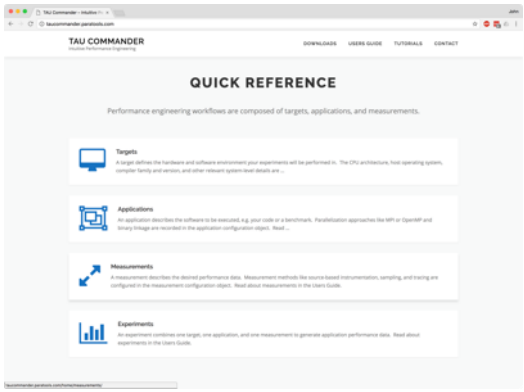

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VOCABULARY

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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*"
- *Phase* profiles
  - Flat profiles under a phase (nested phases allowed)
  - Default "main" phase
  - Supports static or dynamic (e.g. per-iteration) phases

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Direct Observation Events

- Interval events (begin/end events)
  - Measures exclusive & inclusive durations between events
  - Metrics monotonically increase
  - Example: Wall-clock timer
- Atomic events (trigger with data value)
  - Used to capture performance data state
  - Shows extent of variation of triggered values (min/max/mean)
  - Example: heap memory consumed at a particular point

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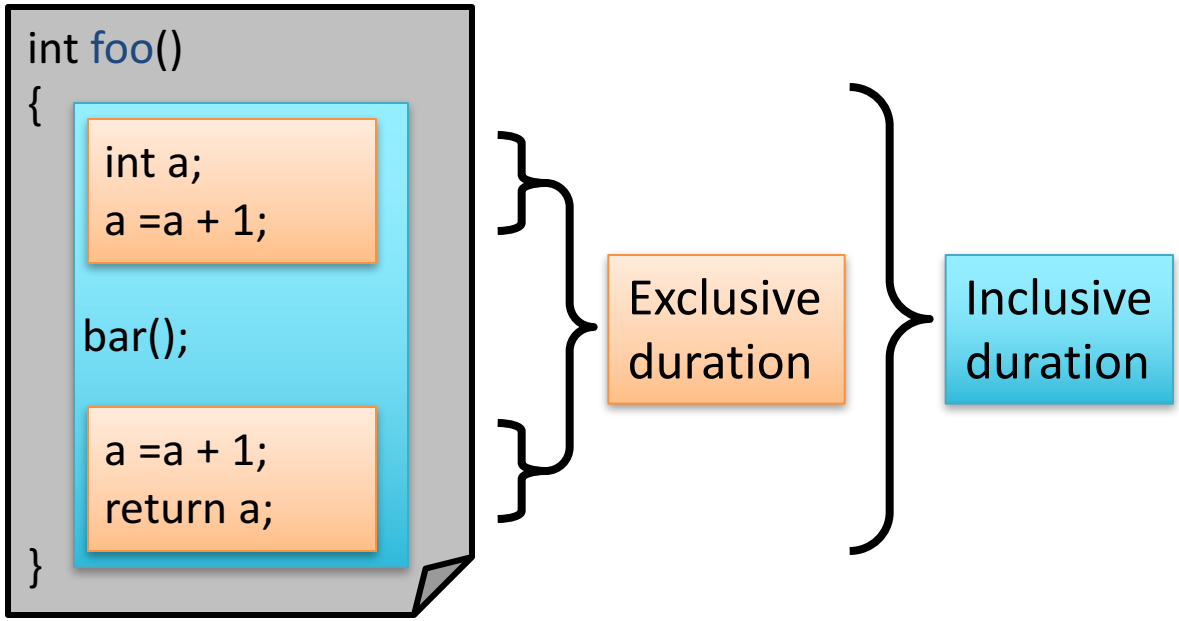
Inclusive vs. Exclusive Measurements

- Exclusive measurements for region only
- Inclusive measurements includes child regions



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