ECP Community BOF: Observing GPU Performance Using the TAU Performance System[®]

March 30, 2021, 10am PT https://www.exascaleproject.org/event/ecp-community-bof-days-2021/

Sameer Shende, Kevin Huck, Allen Malony, Wyatt Spear, Camille Coti Performance Research Laboratory, OACISS, University of Oregon http://tau.uoregon.edu/TAU_BoF_Mar21.pdf











Challenges

- With growing hardware complexity, it is getting harder to accurately measure and optimize the performance of our HPC and AI/ML workloads.
- TAU Performance System[®]:
 - Deliver a scalable, portable, performance evaluation toolkit for HPC and AI/ML workloads
 - http://tau.uoregon.edu



TAU Performance System®

Parallel performance framework and toolkit

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





TAU Performance System

Instrumentation

- Fortran, C++, C, UPC, Java, Python, Chapel, Spark
- Automatic instrumentation

Measurement and analysis support

- MPI, OpenSHMEM, ARMCI, PGAS, DMAPP
- pthreads, OpenMP, OMPT interface, hybrid, other thread models
- GPU, ROCm, CUDA, OpenCL, OpenACC
- Parallel profiling and tracing

Analysis

- Parallel profile analysis (ParaProf), data mining (PerfExplorer)
- Performance database technology (TAUdb)
- 3D profile browser



Application Performance Engineering using TAU

- How much time is spent in each application routine and outer *loops*? Within loops, what is the contribution of each *statement*? What is the time spent in OpenMP loops? In kernels on GPUs. How long did it take to transfer data between host and device (GPU)?
- How many instructions are executed in these code regions?
 Floating point, Level 1 and 2 data cache misses, hits, branches taken? What is the extent of vectorization for loops?
- What is the memory usage of the code? When and where is memory allocated/de-allocated? Are there any memory leaks? What is the memory footprint of the application? What is the memory high water mark?
- How much energy does the application use in Joules? What is the peak power usage?
- What are the I/O characteristics of the code? What is the peak read and write *bandwidth* of individual calls, total volume?
- How does the application *scale*? What is the efficiency, runtime breakdown of performance across different core counts?



Instrumentation

Add hooks in the code to perform measurements

• Source instrumentation using a preprocessor

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

Compiler-based instrumentation

- Use system compiler to add a special flag to insert hooks at routine entry/exit.
- Requires recompiling using TAU compiler scripts (tau_cc.sh, tau_f90.sh...)
- Runtime preloading of TAU's Dynamic Shared Object (DSO)
 - No need to recompile code! Use **mpirun tau_exec ./app** with options.



Profiling and Tracing

Description Constraint Astep Logs: POINT_SOLVER: POINT_SOLVE_5 [[point_solver.F90] [2757,51-(2917,19]] Logs: POINT_SOLVER: POINT_SOLVER.STR 10:329 36:40 PUNSSD_PC_CON: PUNSSD_READ_VERD_CON_SOLVER: STR 10:338 POINT_SOLVER: POINT_SOLVER: TT [[[func_perGas: 690] (13023,14]] 7:338 POINT_SOLVER: TORE: CONV_DUPT [[[func_perGas: 190] (5204,14]] 0:667 POINT_LU_DOD: LLS [[[foint_mincolverG0] (1204,3)-[1023,21

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

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

Tracing shows you when the events take place on a timeline





 Tracing shows you when the events take place on a timeline

Instrumentation

- Direct and indirect performance observation
- Instrumentation invokes performance measurement
- Direct measurement with *probes*
- Indirect measurement with periodic sampling or hardware performance counter overflow interrupts
- Events measure performance data, metadata, context, etc.
- User-defined events
 - Interval (start/stop) events to measure exclusive & inclusive duration
 - Atomic events take measurements at a single point
 - Measures total, samples, min/max/mean/std. deviation statistics
 - **Context events** are atomic events with executing context
 - Measures above statistics for a given calling path



Inclusive vs. Exclusive Measurements

- Performance with respect to code regions
- Exclusive measurements for region only
- Inclusive measurements includes child regions





Inclusive Measurements

| • • • | | TAU: ParaProf: node 0 - fun3d_d19.ppk | |
|---|--|--|--|
| Metric: TIME Value: Inclusive Units: seconds | | | |
| 221.305 221.304 197.989 195.577 195.569 | 61.927 61.28 61.275 61.258 59.068 57.635 57.152 56.882 54.402 53.103 52.866 52.756 52.747 52.744 36.231 36.231 27.474 27.474 22.707 22.694 20.916 16.726 16.726 16.657 14.159 13.852 | .TAU application NODET [[main.f90] {4,1}-{35,17]] FLOW::ITERATE [[flow.F90] {1692,14]] FLOW::STEP_SOLVER [[flow.F90] {1845,14]] RELAX_STEADY::RELAX [[relax_steady.f90] {30,3}-{307,22]] UPDATE_MEAN::UPDATE_LINEAR_SYSTEM_MEAN [[update_mean.F90] {195,3}-{275,42]] UPDATE_MEAN::UPDATE_JACOBIAN_DRIVER_MEAN [[update_mean.F90] {40,3}-{505,44]] UPDATE_MEAN::UPDATE_JACOBIAN_DRIVER_MEAN [[update_mean.F90] {40,3}-{505,44]] UPDATE_MEAN::UPDATE_JACOBIAN [[ill_jacobians.f90] {19,3}-{341,30]] GCR_SOLVE::GCR_SOLVER_QSET [[gcr_solve.f90] {47,3}-{415,32]] GCR_SOLVE_UTIL::GCR_PRECONDITIONER_QSET [[gcr_solve_util.f90] {40,3}-{131,40]] POINT_SOLVEE::POINT_SOLVE [[point_solver.F90] {31,3}-{214,28]] UPDATE_MEAN::UPDATE_RHS_MEAN [[update_mean.F90] {102,3}-{185,32]] RELAX_MEAN::RELAX [[relax_mean.f90] {22,3}-{84,22]] LINEARSOLVE_NODIVCHECK::NODIVCHECK_RELAX_Q [[linearsolve_nodivcheck.F90] {56,14]] UPDATE_MEAN::RESIDUAL_S [[update_mean.F90] {27,3}-{279,25]] FLUX::RESIDUAL_COMPRESSIBLE [[flux.f90] {25,3}-{592,38]] POINT_SOLVER::POINT_SOLVE_5 [[point_solver.F90] {2757,5}-{2917,19]} JACOBIAN_VISCOUS::IDCGLP [[jacobian_viscous.f90] {20,1}-{1584,22]} FLUX::RESIDUAL_COMPRESSIBLE [[flux.f90] {23,1}-{341,41}] Loop: JACOBIAN_VISCOUS::EDCGLP [[jacobian_viscous.f90] {24,14]} Loop: JACOBIAN_VISCOUS::EDCGLP [[jacobian_viscous.f90] {24,14]} Loop: JACOBIAN_VISCOUS::EDCGLP [[jacobian_viscous.f90] {24,14]} Loop: JACOBIAN_VISCOUS::EDCGLP [[jacobian_viscous.f90] {24,14]} Loop: FLUX_PERFGAS::R0LFLUX [[flux_perfgas.f90] {337,14]} FLUX_PERFGAS::R0E_FLUX [[flux_perfgas.f90] {337,14]} FLUX_PERFGAS::R0E_FLUX [[flux_perfgas.f90] {337,14]} FLUX_PERFGAS::R0E_FLUX [[flux_perfgas.f90] {337,14]} PPARTY_PREPROCESSOR::PPARTY_PREPROCESS [[party_preprocessor.f90] {28,14]} PPARTY_PREPROCESSOR::PPARTY_READ_CRID [[puns3d_io_c2n.f90] {353,14]} PUNS3D_IO_C2N::PUNS3D_READ_VCRID_C2N_SM [[puns3d_io_c2n.f90] {353,14]} PUNS3D_IO_C2N::PUNS3D_READ_VCRID_C2N_SM [[puns3d_io_c2n.f90] {353,14]} PUNS3D_IO_C2N::PUNS3D_READ_VCRID_C2N_SM [[puns3d_io_c2n.f90] { | |



Exclusive Time





How much data do you want?





ParaProf Profile Browser



% paraprof

ParaProf Profile Browser





ParaProf 3D Profile Browser

000

ParaProf Visualizer: cmod.128x128.128DC.ppk/128x128/aorsa2d/taudata/rs/sameer/Users/







TAU – ParaProf 3D Visualization



% paraprof app.ppk Windows -> 3D Visualization -> Bar Plot (right pane)

TAU – 3D Communication Window



% export TAU_COMM_MATRIX=1; mpirun ... tau_exec ./a.out % paraprof ; Windows -> 3D Communication Matrix



Tracing: Jumpshot (ships with TAU)



Tracing: Chrome Browser

| Contracting + | | | | | |
|---|---|---|------------------------------|---------------------------------|---|
| $\leftarrow \rightarrow \mathbb{C}$ \textcircled{O} Chrome chrome://tracing | | | | | ९ ☆ ♀ ⊖ : |
| Record Save Load matmult.json | | | F | Processes View Options | $\leftarrow \rightarrow \gg$? |
| | 380 ms | 385 ms | · · | 39 | 90 ms |
| ✓ Process 0 | | | | | х п |
| ▼ 0 | | .TAU app | olication | | lie |
| | | MAIN [(matmult.190 |); {39,7}-{132,22}] | | |
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| 79 items selected. Slices (79) | | | | | |
| Name 🗢 | Wall Duration \bigtriangledown Self time \checkmark | Average Wall Duration \bigtriangledown Occurrences \bigtriangledown | Event(s) | Link | |
| MULTIPLY_MATRICES [{matmult.f90} {25,7} | <u>}-{37,38}]</u> ੍ 114.459 ms 114.459 ms | 4.239 ms 27 | Incoming flow | MPI | |
| MPI_Send()_ | 0.157 ms 0.157 ms | 0.007 ms 23 | Incoming flow | MPI | |
| MPI_Recv()_ | 0.994 ms 0.994 ms | 0.043 ms 23 | Incoming flow | MPI | |
| .TAU application | 2,274.680 ms 0.174 ms | 758.227 ms 3 | Incoming flow | MPI | |
| MAIN [{matmult.f90} {39,7}-{132,22}] | 2,274.506 ms 13.845 ms | 758.169 ms 3 | Incoming flow | MPI | |
| Totals | 4,664.796 ms 129.629 ms | 59.048 ms 79 | Incoming flow | MPI | |
| | | | Incoming flow | MPI | |
| Selection start | | 0.196 ms | Incoming flow | MPI | |
| Selection extent | | 759.696 ms | Incoming flow | MPI | |
| | | | Incoming flow | MPI | |
| Spapz Pro | x | | Incoming flow | MPI | |
| Shapz PIO | | | incoming flow | | |

% export TAU_TRACE=1

% mpirun –np 256 tau_exec ./a.out

% tau_treemerge.pl; tau_trace2json tau.trc tau.edf –chrome –ignoreatomic –o app.json

Chrome browser: chrome://tracing (Load -> app.json)

Vampir [TU Dresden] Timeline: Kokkos

| | | | | X Trac | e View - /home/sssl | hend/workshop/kol | kkos/kokkos-miniap | ps/lulesh-2.0/kokko | s-minimal-cpu/trace | s.otf2 * - ' | Vampir | | | |
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| Master thread | | | _ | | | | | | | × Ko | kkos::pa[device=0] [87] | us (2.13%)] | | |
| Thread 1 | .TAU application | | | | | | .TAU application | | | | | | | |
| Thread 2 | .TAU application | | | | | | .TAU appli | cation | | Op | en,0}] [465 μs (11.36%) | | | |
| Thread 3 | .TAU application | | | | | | | .TAU applicatio | n | | | | | |
| Thread 4 | .TAU application | | | | | | | TAU application | | | | | | |
| Thread 5 | .TAU application | | | | _ | | .TAU | application | | | | | | |
| Thread 6 | .TAU application | | | _ | _ | _ | | TAU application | | | | | | |
| Thread 7 | .TAU application | | | | | | .TAU ap | plication | | | | | | |
| Thread 8 | .TAU application | | | | | | | .TAU | application | | | | | 2 260 mc (55 4204) |
| Thread 9 | .TAU application | | | | | | .TAU ap | plication | | | | | | 2.209 ms (55.43%) |
| Thread 10 | .TAU application | | _ | | _ | | TAU | application | | | [1.109 ms (27.1%)] | | | |
| Thread 11 | .TAU application | | | | | | | .TAU application | | | | | | |
| Thread 12 | .TAU application | | _ | | | | | .TAU a | plication | | | | | |
| Thread 13 | .TAU application | | _ | | | _ | .TAU applicati | on | | | | | | |
| Thread 14 | .TAU application | | | | | | .TAU a | pplication | | | | | | |
| Thread 15 | .TAU application | | | | | | | .TAU applica | tion | | | | | |
| Thread 16 | .TAU application | | | | _ | | | | | | | | | |
| Thread 17 | .TAU application | | | | _ | | .TAU applica | ation | | | Evention Symmetry | Context View | | |
| Thread 18 | .TAU application | | | | | _ | .TAU application | r | | | Punction Summary | | | + |
| Thread 19 | .TAU application | | | | | | .TAU applicati | on | | Dis | pperty V inlav F | unction Summary | | - |
| Thread 20 | .TAU application | | | | | | | .TAU | application | Filt | er A | Il Processes | | |
| ••• | \mathbf{X} | Call Tree - /home/s | sshend/workshop/k | okkos/kokkos-mini | apps/lulesh-2.0/kok | kos-minimal-cpu/t | traces.otf2 * - Vamp | bir | | Fur | nction | Kokkos::parallel_for CalcEne | rgyForElems E [device | -0] |
| All Processes | | | | | | | | | * | | _ | Function Legend | | |
| Functions | | | | | | Min Inclusive Ti | me Max Inclus | sive Time | | • | TAU_KOKKOS Kokkos::parallel for | CalcKinematicsForElems (devi | ice=01 | - |
| TAU appli 🗖 🖛 | cation | orElems E Idevice | -01 | | | 9 | 4.527 µs | | 94.527 µs | | Kokkos::parallel_for | CalcMonotonicQGradientsFor | Elems [device=0] | |
| 👻 🖪 Ope | mMP_PARALLEL_REGION: K | okkos::Impl::Paral | lelFor<_INTERNAL_S | 9_lulesh_cc_caa5d | Sc5::CalcEnergyFor | 7 | 9.000 µs | | 79.000 µs | | Kokkos::parallel_for | CalcPositionForNodes (device | =0] | |
| Callers Calle | es | AFFORT PARAL | alertre intreastat u | LINER PP Passing | Chill alc enarchiente | | 2 1001 100 | | 77 000 04 | 1 | Kokkos::parallel_for Kokkos::parallel_for | CalcPressureForElems A [dev CalcPressureForElems B [dev | ice=0] ice=0] | |
| OpenMP PAR | ALLEL REGION: Kokkos::Im | pl::ParallelFor< IN | VTERNAL 9 Julesh c | c caa5d6c5::CalcE | nergyForElems(do | uble*, double*, do | uble*, double*, dou | uble*, double*, dou | ole*, double*, double | 2 | Kokkos::parallel_for | CalcSoundSpeedForElems (de CalcVelocityForNodes Idenice | evice=0] | |
| | | | | - | | | | | | | Kokkos::parallel_for | EvalEOSForElems A [device=0 | 20, | |
| | | | | | | | | | | | Kokkos::parallel_for Kokkos::parallel_for | EvalEOSForElems B [device=0 EvalEOSForElems C [device=0 |)] | |
| Find Function | | | | | | | | Bre | Nove | | Kokkos::parallel_for Kokkos::parallel_for | EvalEOSForElems D [device=0 EvalEOSForElems E [device=0 | 2] | |
| Pind Punction: | | | | | | | | Pre | Nous Next | P 4 | | Pullocrafian Pidada | 1 | |
| | | | | | | | | | | | | | | |

% export TAU_TRACE=1; export TAU_TRACE_FORMAT=otf2 % tau_exec -ompt ./a.out

% vampir traces.otf2 &

Performance Data Measurement



- Fine-grain control
- Calls inserted
 into code

Indirect via Sampling



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



Sampling



- Running program is periodically interrupted to take measurement
 - Timer interrupt, OS signal, or HWC overflow
 - Service routine examines return-address stack
 - Addresses are mapped to routines using symbol table information
- Statistical inference of program behavior
 - Not very detailed information on highly volatile metrics
 - Requires long-running applications
- Works with unmodified executables

| int main() | |
|--|--|
| int i; | |
| <pre>for (i=0; i < 3; i++) foo(i);</pre> | |
| return 0; } | |
| void foo(int i) { | |
| if (i > 0) foo(i - 1); | |
| } | |
| | |



Instrumentation





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)



Event Based Sampling (EBS)





Event Based Sampling (EBS): QMCPack

EXASCALE COMPUTING

| TAU: ParaProf: Statistics for: node 0, thread 0 - qmcpack_64p.ppk | | | | | | | | | | |
|--|----------------|-----------------|--------|-------------|--|--|--|--|--|--|
| Name | Fxclusive TIME | Inclusive TIMF⊽ | Calls | Child Calls | | | | | | |
| | 979.071 | 1.066.528 | 1 | 493 | | | | | | |
| ICONTEXT].TAU application | | 975.151 | 32.481 | 0 | | | | | | |
| ■ MPI Allreduce() | 35.346 | | 52 | 0 | | | | | | |
| <pre>CONTEXT] MPI_Allreduce()</pre> | 0 | 35.37 | 1,179 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_MRAILI_Get_next_vbuf [{/builddir/build/BUILD/mvapich2-2.3/src/n | 16.109 | 16.109 | 537 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid | 10.71 | 10.71 | 357 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid, | 10.23 | 10.23 | 341 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid} | 0.27 | 0.27 | 9 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid} | 0.09 | 0.09 | 3 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid} | 0.03 | 0.03 | 1 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid} | 0.03 | 0.03 | 1 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/ | 0.03 | 0.03 | 1 | 0 | | | | | | |
| [SAMPLE] MPIDI_CH3I_MRAILI_Cq_poll_ib [{/builddir/build/BUILD/mvapich2-2.3/src/mpid} | 0.03 | 0.03 | 1 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_SMP_read_progress [{/builddir/build/BUILD/mvapich2-2.3/src/mpi | 1.98 | 1.98 | 66 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_SMP_pull_header [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/c | 1.77 | 1.77 | 59 | 0 | | | | | | |
| [SAMPLE] GetSeqNumVbuf [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/ch3/channels/n | 1.23 | 1.23 | 41 | 0 | | | | | | |
| [SAMPLE] UNRESOLVED /usr/lib64/libmlx5.so.1.0.0 | 1.05 | 1.05 | 35 | 0 | | | | | | |
| [SAMPLE] ibv_poll_cq [{/usr/include/infiniband/verbs.h} {2456}] | 0.96 | 0.96 | 32 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_Progress [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/ch3/cha | 0.6 | 0.6 | 20 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_MRAILI_Test_pkt [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/c | 0.24 | 0.24 | 8 | 0 | | | | | | |
| SUMMARY] MPIDU_Sched_progress [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/comm | 0.21 | 0.21 | 7 | 0 | | | | | | |
| [SAMPLE] pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] | 0.18 | 0.18 | 6 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_read_progress [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/ch] | 0.15 | 0.15 | 5 | 0 | | | | | | |
| SUMMARY] MPIDU_Sched_progress_state [{/builddir/build/BUILD/mvapich2-2.3/src/mpid/u | 0.09 | 0.09 | 3 | 0 | | | | | | |
| SUMMARY] MPIDI_CH3I_SHMEM_COLL_GetShmemBuf [{/builddir/build/BUILD/mvapich2-2.3 | 0.09 | 0.09 | 3 | 0 | | | | | | |
| ► ■ MPI_Reduce() | 31.996 | 31.996 | 9 | 0 | | | | | | |
| ► ■ MPI_Gatherv() | 9.433 | 9.433 | 230 | 0 | | | | | | |
| ► ■ MPI_Bcast() | 5.452 | 5.452 | 71 | 0 | | | | | | |
| ► ■ MPI_Init() | 2.356 | 2.356 | 1 | 2 | | | | | | |
| ► ■ MPI_Finalize() | 1.333 | 1.351 | 1 | 4 | | | | | | |

Ran for 1066.528 seconds. Outside of MPI calls, TAU can explain 975.151 seconds out of 979.071 seconds of exclusive time using EBS!

Event Based Sampling (EBS) shows statement level information

|) | T/ | AU: ParaProf: Function Data Window: qr | ncpack_64p.ppk | |
|---------------|----------------------|--|--------------------------|--------------------------------------|
| .TAU applicat | ion => MPI_Allreduce | e() => [CONTEXT] MPI_ | Allreduce() => [SUMMARY |] |
| _CH3I_MRAILI_ | Cq_poll_ib | _ | | |
| dir/build/BUI | LD/mvapich2-2.3/sro | c/mpid/ch3/channels/r | nrail/src/gen2/ibv_chann | el_manager.c}] => |
| E] MPIDI_CH3 | I_MRAILI_Cq_poll_ib | | | |
| ir/build/BUI | LD/mvapich2-2.3/sro | c/mpid/ch3/channels/r | nrail/src/gen2/ibv_chann | el_manager.c} { <mark>1018</mark> }] |
| ame: TIME | | | | |
| clusive | | | | |
| conds | | | | |
| | | | | |
| | | | | max |
| | | | 3.989 | min |
| | | | 4.382 | std. dev. |
| | 19.319 | | | mean |
| | | 10.23 | | node 0, thread 0 |
| | 19.47 | | | node 1, thread 0 |
| | 17.000 | | | node 2, thread 0 |
| 22.02 | 17.999 | | | node 3, thread 0 |
| 22.92 | 10.74 | | | node 5, thread 0 |
| | 19.74 | | | node 6 thread 0 |
| | 16.92 | | | node 7, thread 0 |
| 23.4 | 10.52 | | | node 8 thread 0 |
| 21.0 | 3 | | | node 9, thread 0 |
| 20. | .52 | | | node 10, thread 0 |
| 1 | .9.98 | | | node 11, thread 0 |
| 21.0 | 6 | | | node 12, thread 0 |
| 20.9 | | | | node 13, thread 0 |
| | 19.68 | | | node 14, thread 0 |
| | | | 5.399 | node 15, thread 0 |
| 20 | 0.16 | | | node 16, thread 0 |
| 20 | 9.98 | | | node 18 thread 0 |
| 1 | 18 96 | | | node 19 thread 0 |
| 3.639 | 10:00 | | | node 20, thread 0 |
| 20. | .52 | | | node 21, thread 0 |
| 1 | .9.92 | | | node 22, thread 0 |
| | 16.801 | | | node 23, thread 0 |
| 23.19 | | | | node 24, thread 0 |
| | | 12.57 | | node 25, thread 0 |
| | | 13.2 | | node 26, thread 0 |
| 21 00 | | | 0.00 | node 27, thread 0 |
| 21.99 | 10.44 | | | node 28, thread 0 |
| 20 | 19.44 <u> </u> | | | node 30 thread 0 |
| 20 | 61 | | | node 31 thread 0 |
| 20. | | | | node 32, thread 0 |
| 20.6 | 71 | | | node 33, thread 0 |
| | 19.89 | | | node 34, thread 0 |
| | 19.38 | | | node 35, thread 0 |
| 4.15 | | | | node 36, thread 0 |
| | 19.5 | | | node 37, thread 0 |
| | 19.29 | | | node 38, thread 0 |
| | 19.71 | | | node 39, thread 0 |

File: ibv_channel_manager.c Line: 1018



Event Based Sampling without symbol information (-g): QMCPack





EBS introspection in system libraries

| TAU: ParaProf: Statistics for: node 1, thread 0 - hdf5_ex1.ppk | | | | | | | | |
|---|----------------|----------------|-------|-------------|--|--|--|--|
| | | | | | | | | |
| Name | Exclusive TIME | Inclusive TIME | Calls | Child Calls | | | | |
| ► ■.TAU application | 0.097 | 9.271 | 1 | 4,979 | | | | |
| ▼ □ MPI_Barrier() | 4.561 | 4.561 | 5 | 0 | | | | |
| [CONTEXT] MPI_Barrier() | 0 | 4.59 | 153 | 0 | | | | |
| [SAMPLE] pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] | 1.89 | 1.89 | 63 | 0 | | | | |
| [SAMPLE] PAMI_Context_advancev [{/autofs/nccs-svm1_sw/summit/.swci | 0.96 | 0.96 | 32 | 0 | | | | |
| [SAMPLE] start_libcoll_blocking_collective [{/autofs/nccs-svm1_sw/summ] | 0.6 | 0.6 | 20 | 0 | | | | |
| [SAMPLE] PAMI::Device::IBV::Device::advance() [{/autofs/nccs-svm1_sw/su | 0.48 | 0.48 | 16 | 0 | | | | |
| [SAMPLE] UNRESOLVED /usr/lib64/libmlx5.so.1.0.0 | 0.18 | 0.18 | 6 | 0 | | | | |
| [SAMPLE] pthread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] | 0.18 | 0.18 | 6 | 0 | | | | |
| SUMMARY] LIBCOLL_Advance_pami [{/SMPI_build_dir | 0.15 | 0.15 | 5 | 0 | | | | |
| [SAMPLE] verbs_get_exp_ctx [{pami.cc} {0}] | 0.09 | 0.09 | 3 | 0 | | | | |
| SUMMARY] LIBCOLL_Advance [{/SMPI_build_dir | 0.06 | 0.06 | 2 | 0 | | | | |
| ▼ ■ MPI_Bcast() | 2.089 | 2.089 | 4,509 | 0 | | | | |
| [CONTEXT] MPI_Bcast() | 0 | 2.07 | 69 | 0 | | | | |
| [SAMPLE] pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] | 0.66 | 0.66 | 22 | 0 | | | | |
| [SAMPLE] PAMI_Context_advancev [{/autofs/nccs-svm1_sw/summit/.swci | 0.51 | 0.51 | 17 | 0 | | | | |
| [SAMPLE] start_libcoll_blocking_collective [{/autofs/nccs-svm1_sw/summ] | 0.27 | 0.27 | 9 | 0 | | | | |
| [SAMPLE] PAMI::Device::IBV::Device::advance() [{/autofs/nccs-svm1_sw/su | 0.21 | 0.21 | 7 | 0 | | | | |
| [SAMPLE] UNRESOLVED /usr/lib64/libmlx5.so.1.0.0 | 0.15 | 0.15 | 5 | 0 | | | | |
| [SAMPLE] pthread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] | 0.12 | 0.12 | 4 | 0 | | | | |
| SUMMARY] LIBCOLL_Advance_pami [{/SMPI_build_dir | 0.09 | 0.09 | 3 | 0 | | | | |
| [SAMPLE] verbs_get_exp_ctx [{pami.cc} {0}] | 0.03 | 0.03 | 1 | 0 | | | | |
| SUMMARY] LIBCOLL_Advance [{/SMPI_build_dir | 0.03 | 0.03 | 1 | 0 | | | | |
| MPI_Finalize() | 0.624 | 0.681 | 1 | 55 | | | | |

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[®] 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
- $MPI + C\overline{U}DA$
 - PMPI + CUPTI interfaces
- MPI + Intel [®] OneAPI DPC++/SYCL
- PMPI + Level Zero interfaces
- OpenCL + ROCm
 - Rocprofiler + OpenCL instrumentation 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

Kokkos

- Provides abstractions for node level parallelism (X in MPI+X)
- Productive, portable, and performant shared-memory programming model
- Helps you create single source performance portable codes
- Provides data abstractions
- C++ API for expressing parallelism in your program
- Aggressive compiler transformations using C++ templates
- · Low level code targets backends such as OpenMP, Pthread, CUDA
- Creates a problem for performance evaluation tools
- Gap: performance data and higher-level abstractions
- Solution: Kokkos profiling API for mapping performance data
- https://kokkos.org Sandia National Laboratories, NM



Kokkos API use in ExaMiniMD



ExaMiniMD: TAU Phase

| 000 | TAU: ParaProf: Statistics for: node 0, thread 0 - examinin | nd_ompt_phase.ppk | | |
|--|--|-------------------|-------|-------------|
| | | | | |
| Name△ | Exclusive TIME | Inclusive TIME | Calls | Child Calls |
| TAU application | 0.143 | 96.743 | 1 | 832 |
| Comm::exchange | 0.001 | 0.967 | 6 | 142 |
| Comm::exchange_halo | 0.001 | 4.702 | 6 | 184 |
| Comm::update_halo | 0.004 | 31.347 | 95 | 1,330 |
| Kokkos::parallel_for CommMPI::halo_update_pack [device=0] | 0.002 | 0.506 | 190 | 190 |
| Kokkos::parallel_for CommMPI::halo_update_self [device=0] | 0.003 | 0.597 | 380 | 380 |
| Kokkos::parallel_for CommMPI::halo_update_unpack [device=0] | 0.002 | 0.97 | 190 | 190 |
| MPI_Irecv() | 0.001 | 0.001 | 190 | 0 |
| MPI_Send() | 29.268 | 29.268 | 190 | 0 |
| MPI_Wait() | 0.001 | 0.001 | 190 | 0 |
| OpenMP_Implicit_Task | 0.041 | 1.985 | 760 | 760 |
| OpenMP_Parallel_Region parallel_for <kokkos::rangepolicy<commmpi::ta< p=""></kokkos::rangepolicy<commmpi::ta<> | a 0 | 0.504 | 190 | 190 |
| OpenMP_Parallel_Region parallel_for <kokkos::rangepolicy<commmpi::ta< p=""></kokkos::rangepolicy<commmpi::ta<> | a 0.08 | 0.968 | 190 | 190 |
| OpenMP_Parallel_Region void Kokkos::parallel_for <kokkos::rangepolicy<< p=""></kokkos::rangepolicy<<> | 0.001 | 0.594 | 380 | 380 |
| OpenMP_Sync_Region_Barrier parallel_for <kokkos::rangepolicy<commm< p=""></kokkos::rangepolicy<commm<> | F 0.489 | 0.489 | 190 | 0 |
| OpenMP_Sync_Region_Barrier parallel_for <kokkos::rangepolicy<commm< p=""></kokkos::rangepolicy<commm<> | F 0.875 | 0.875 | 190 | 0 |
| OpenMP_Sync_Region_Barrier void Kokkos::parallel_for <kokkos::rangepo< p=""></kokkos::rangepo<> | I 0.58 | 0.58 | 380 | 0 |

Comm::update_halo phase in TAU ParaProf's Thread Statistics Table



Event-based Sampling (EBS): CabanaMD on an IBM AC922 with NVIDIA V100 GPUs

| Name Exclusive Inclusive Calls Child Calls * • TAU application 0.655 5.132 1 2.478 * • Comm:update_halo 0.255 5.132 1 2.478 * • Comm:update_halo 0.012 3 0 <td< th=""><th>TAU: ParaProf: Statistics for: node 0, thread 0 - cabana.ppk</th><th></th><th></th><th></th><th></th></td<> | TAU: ParaProf: Statistics for: node 0, thread 0 - cabana.ppk | | | | |
|---|--|-----------|-------------|---------|------------|
| Name Exclusive Inclusive Inclusive Calls Child Calls * TAU application Kokkos sample within Comm::update_halo 0.129 1.634 95 21.755 * Comm::update_halo 0.129 1.634 95 21.755 * Couldbecksynchroniz 0.911 0.031 0.03 0.031 0.031 * Couldbecksynchroniz 0.911 | | | | | |
| * U.TAU application * Ocmm::update_halo * Comm::update_halo * Comm::update_halo * Comm::update_halo 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.12 3.1634 0.03 0.12 3.043 0.03 1.044 0.09 0.09 2.00 0.09 2.00 0.09 3.043 0.09 3.043 0.09 0.09 3.043 0.03 0.03 0.03 1.044 0.040 0.09 3.043 0.045 0.05 0.05 0.05 0.05 0.05 0.05 0.06 < | Name | Exclusive | Inclusive 🗸 | Calls C | hild Calls |
| * ECONTEXT Comm::update_halo 0.129 1.634 95 21.755 * ECONTEXT Comm::update_halo 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 2 0.09 0.09 0.09 2 0.09 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.03 </td <td>TAU application</td> <td>0.65</td> <td>5 5.132</td> <td>1</td> <td>2,424</td> | TAU application | 0.65 | 5 5.132 | 1 | 2,424 |
| * [CONTEXT] Communiqueste_halo 0 0.12 3 0 • [SAMPLE]_strengewers [1] (0] 0.09 0.09 2 0 • CudDeviceSynchronize 0.99 0.09 3.043 0 • CudDeviceSynchronize 0.91 0.93 3.043 0 • CUDDeviceSynchronize 0.91 0.921 3.043 0 • CUDDeviceSynchronize 0.91 0.921 0.921 3.043 0 • SUMMER[LAMMPS_RandomVelocityGeom::reset(int, double*) [I/g/g20/reveeS/pr/CabanaMD/src/input.h] 0.72 0.72 9 • [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [I/g/g20/reveeS/pr/CabanaMD/src/input.h] 0.03 0.06 2 • [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [I/g/g20/reveeS/pr/CabanaMD/src/input.h] 0.03 1 0 • [SAMPLE] Input:::reset_latticeComm*) [I/g/g20/reveeS/pr/CabanaMD/src/input.pp] 0.03 1 0 0.03 1 • [SAMPLE] Input:::reset_latticeComm*) [I/g/g20/reveeS/pr/CabanaMD/src/input.pp] 0.03 0.03 1 0 • [SAMPLE] Input:::reset_latticeComm*) [I/g/g20/reveeS/pr/CabanaMD/src/input.pp] 0.03 1 0 0.03 1 0 | Comm::update_halo Kokkos sample within Comm::update_halo | 0.129 | 9 1.634 | 95 | 21,755 |
| | T [CONTEXT] Comm::update_halo | (| 0.12 | 3 | 0 |
| [SAMPLE] Kokkos::mp::SharedAllocationRecord 0.91 0.03 0.03 1 * UcudDeviceSynchronize 0.91 0.94 0.054 18 * UcudDeviceSynchronize 0 0.54 18 0 * UCUNTEXTI :TAU application 0 0.54 18 0 * USUMMARY LAMMPS; Random/velocityGeom::resettin, double?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h]] 0.09 0.09 3 0 USAMPLE] LAMMPS; Random/velocityGeom::resettin, double?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h]] 0.06 0.06 2 0 USAMPLE] LAMMPS; Random/velocityGeom::resettin, double?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h] [109] 0.03 0.03 1 0 USAMPLE] LAMMPS; Random/velocityGeom::resettin, double?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h] [109] 0.03 0.03 1 0 USAMPLE] Input::reate_latticeComm?) [[/g/g20/reevs5/pr/CabanaMD/src/input.pp] [751] 0.03 0.03 1 0 USAMPLE] Input::reate_latticeComm?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 USAMPLE] Input::reate_latticeComm?) [[/g/g20/reevs5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 USAMPLE] Input::reate_latticeComm?) [[/g/g20/reevs5/pr/C | SAMPLE]strlen_power8 [{} {0}] | 0.09 | 9 0.09 | 2 | 0 |
| • EcodaDeviceSynchronize 0.991 0.991 3,043 0 • E[SUMMARY] LAMMPS_RandomVelocityCeom::reset(int, double') [[g/g20/reeve5/pr/CabanaMD/src/input.h] [128] 0.09 3 0 • E[SUMMARY] LAMMPS_RandomVelocityCeom::reset(int, double') [[g/g20/reeve5/pr/CabanaMD/src/input.h] [128] 0.09 0.09 3 0 • E[SUMMARY] LAMMPS_RandomVelocityCeom::reset(int, double') [[g/g20/reeve5/pr/CabanaMD/src/input.h] [129] 0.09 0.06 2 00 • E[SUMMARY] Input::reate_lattice(Comm') [[g/g20/reeve5/pr/CabanaMD/src/input.h] [140]] 0.03 0.03 1 0 • E[SUMMARY] Input::reate_lattice(Comm') [[g/g20/reeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 • E[SUMMEL] IAMMPS_RandomVelocityCeom::reset(int, double') [[g/g20/reeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 • E[SUMMARY] Input::reate_lattice(Comm') [[g/g20/reeve5/pr/CabanaMD/src/input.pp] 0.03 0.03 1 0 • E[SUMPLE] Input::reate_lattice(Comm') [[g/g20/reeve5/pr/CabanaMD/src/input.pp] 0.03 0.03 1 0 • E[SUMPLE] Input::reate_lattice(Comm') [[g/g20/reeve5/pr/CabanaMD/src/input.pp] 0.03 0.03 1 0 0.03 1 0 • E[SUMPLE] Input::reate_lattice(Comm') | [SAMPLE] Kokkos::Impl::SharedAllocationRecord <void, void="">::increment(Kokkos::Impl::SharedAllocationRecord<void, void="">*) [{/g/g20/reeve5/bin/CabanaMD</void,></void,> | } 0.03 | 3 0.03 | 1 | 0 |
| * [CONTEXT].TAU application 0 0.54 18 * [SUMMARY] LAMMPS, Random Velocity Ceom:::rest(int, double') [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [128]) 0.09 0.09 3 [SAMPLE] LAMMPS, Random Velocity Ceom:::rest(int, double') [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [129]) 0.09 0.09 3 0 [SAMPLE] LAMMPS, Random Velocity Ceom:::rest(int, double') [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [130]) 0.06 0.06 2 0 [SAMPLE] LAMMPS, Random Velocity Ceom:::rest(int, double') [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [140]] 0.03 0.03 1 0 [SAMPLE] Input:::reste_lattice(Comm') [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Input:::reste_lattice(Comm') [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Input::::reste_lattice(Comm') [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Input::::reste_lattice(Comm') [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Input:::::::::::::::::::::::::::::::::::: | cudaDeviceSynchronize | 0.99 | 0.991 | 3,043 | 0 |
| * [SUMMARY] LAMMPS_RandomVelocityGeom::rest(int, double*) [l/g/g20/reeve5/pr/CabanaMD/src/input.h] [128] 0.09 0.09 3 0 [SAMPLE] LAMMPS_RandomVelocityGeom::rest(int, double*) [l/g/g20/reeve5/pr/CabanaMD/src/input.h] [129] 0.09 0.09 3 0 [SAMPLE] LAMMPS_RandomVelocityGeom::rest(int, double*) [l/g/g20/reeve5/pr/CabanaMD/src/input.h] [130] 0.06 0.06 2 0 [SAMPLE] LAMMPS_RandomVelocityGeom::rest(int, double*) [l/g/g20/reeve5/pr/CabanaMD/src/input.tpp] 0.15 0.15 0.15 0 [SAMPLE] Input::create_latticeComm*) [l/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Input::create_latticeComm*] [l/g/g20/reeve5/pr/CabanaMD/src/input.cpp] 0.03 0.03 1 0 [SAMPLE] Instrumented Int, unsigned I | Television [CONTEXT] .TAU application | (| 0.54 | 18 | 0 |
| SAMPLE LAMMS_RandomVelocityCeom::reset(int, double)! [//g/20/reveS/pr/CabanaM0/src/input.h] [128]] 0.09 3 0 SAMPLE LAMMS_RandomVelocityCeom::reset(int, double)! [//g/20/reveS/pr/CabanaM0/src/input.h] [130]] 0.06 0.06 2 0 SAMPLE LAMMS_RandomVelocityCeom::reset(int, double)! [//g/20/reveS/pr/CabanaM0/src/input.h] [130]] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.cp] [745]] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.cp] [751] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.cp] [751] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.cp] [713] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.cp] [714] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.h] 0.03 0.03 1 0 ISUMMARY Input::create_lattice(Comm)! [//g/20/reveS/pr/CabanaM0/src/input.h] 0.03 0.03 1 0 ISUMMARY Input::create_lattincline(Intoreate_Lattice) 0.03 | [SUMMARY] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h}] | 0.23 | 7 0.27 | 9 | 0 |
| SAMPLE LAMMPS, Random Velocity Ceom::rest(int, double) [//g/20/reves/pr/CabanaMD/src/input.h] (129)] 0.09 3 0 SAMPLE LAMMPS, Random Velocity Ceom::rest(int, double) [//g/20/reves/pr/CabanaMD/src/input.h] (140)] 0.03 0.03 1 0 * [SVMMARY] I put::create_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.h] [140]] 0.03 0.03 1 0 * [SVMMARY] Input::create_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SVMMARY] Input::create_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SVMMLE] Input::create_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SVMMLE] Input::create_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SVMMLE] Instructerate_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SVMMLE] Instructerate_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 * [SVMMLE] Instructerate_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 * [SVMMLE] Instructerate_lattice(Comm?) [//g/20/reves/pr/CabanaMD/src/input.h] 0.03 <td>[SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {128}]</td> <td>0.09</td> <td>9 0.09</td> <td>3</td> <td>0</td> | [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {128}] | 0.09 | 9 0.09 | 3 | 0 |
| [SAMPE] LAMMPS_RandomVelocityGeom::reset(int, double*) [[/g/g20/reve5/pr/CabanaMD/src/input.h}] [10] 0.06 0.06 2 0 * [SUMMARY] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp)] 0.15 0.15 5 0 * [SUMMARY] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp)] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp) [713] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.cp) [713] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.tp) [713] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.tp) [713] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/src/input.tp) [713] 0.03 0.03 1 0 * [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reve5/pr/CabanaMD/sr | [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {129}] | 0.09 | 9 0.09 | 3 | 0 |
| [SAMPLE] LAMMPS_RandomVelocityCeom::reset(int, double') [[/g/g20/revers/pr/CabanaMD/src/input.cp] 0.03 0.03 1 0 ** [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [751] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [751] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [721] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [713] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [713] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] [713] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD/src/input.cp] 0.03 0.03 1 0 [SAMPLE] input::create_lattice(Comm') [[/g/g20/revers/pr/CabanaMD | [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {130}] | 0.00 | 6 0.06 | 2 | 0 |
| * [SUMMARY] Input::create_lattice(Comm?) [[/g/g20/reeves/pr/CabanaMD/src/input.cpp] 0.15 0.15 5 0 * [SVMPLE] Input::create_lattice(Comm?) [[/g/g20/reeves/pr/CabanaMD/src/input.cpp] [655]] 0.03 0.03 1 0 * [SVMPLE] Input::create_lattice(Comm?) [[/g/g20/reeves/pr/CabanaMD/src/input.cpp] [713]] 0.03 0.03 1 0 * [SVMPLE] Input::create_lattice(Comm?) [[/g/g20/reeves/pr/CabanaMD/src/input.cpp] [713]] 0.03 0.03 1 0 * [SVMPLE] Input::create_lattice(Comm?) [[/g/g20/reeves/pr/CabanaMD/src/input.cpp] [713]] 0.03 0.03 1 0 * [SVMMARY] LAMMPS_RandomVelocityCeem::uniform0 [[/g/g20/reeves/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 * SUMMARY] LAMMPS_RandomVelocityCeem::uninform0 [[/g/g20/reeves/pr/CabanaMD/src/input.h] | [SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {140}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [745]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [721]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [721]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [713]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [714]] 0.03 0.03 1 0 [SAMPLE] Insigned Int, unsigned Int, unsigned Int, unsigned Int [[/g/g20/reeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] LAMMPS_RandomVelocityGeom::uniform0 [[/g/g20/reeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] Instrumented Kokkos::sparallel_for forceL[CabanaMVelocityGeom::uniform0 [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [93]] 0.03 0.03 1 0 [SAMPLE] Instrumented Kokkos::sparallel_for 0.03 0.323 1 0 [SAMPLE] Instrumented Kokkos::sparallel_for 0.03 0.03 1 0 [SAMPLE] Instrumented Kokkos::sparallel_for Kokkos::viewriintialization | [SUMMARY] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp}] | 0.1 | 5 0.15 | 5 | 0 |
| [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] (72]] 0.03 0.03 1 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] (713]] 0.03 0.03 1 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] (713]] 0.03 0.03 1 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] (714]] 0.03 0.03 1 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] (714]] 0.03 0.03 1 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpl] 0.06 0.06 2 0 [SAMPLE] Input::reate_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.h]] 0.03 0.03 1 0 [SAMPLE] Input::reate_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [93]] 0.03 0.03 0.03 1 [SAMPLE] Input::reate_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [93]] 0.03 0.03 0.03 1 0 [SAMPLE] Input::reate_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [93] 0.03 0.03 1 0 [SAMPLE] Input::reate_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.h] [93] 0.03 0.03 0.03 | [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {745}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] Input::create_lattice(Comm*) {{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {721}} 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) {{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {713}} 0.03 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) {{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {713}} 0.03 0.03 0.03 1 0 [SAMPLE] instinced long Kokkos::mpsi/veeve5/pr/CabanaMD/src/input.cpp) {724}} 0.06 0.06 2 0 [SAMPLE] instinced long Kokkos::mpsi/veeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] instinced long kokos::mpsi/veeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [Comm::exchange halo Kokkos::mpsi/veeve 0.024 0.323 1 0 | [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {665}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [713]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [714]] 0.03 0.03 1 0 [SAMPLE] Input::create_lattice(Comm*) [[/g/g20/reeve5/pr/CabanaMD/src/input.cpp] [714]] 0.03 0.03 1 0 [SAMPLE] unsigned long Kokkos::impl::ViewOffset <kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::impl::viewoffset< td=""> 0.03 0.03</kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::viewoffset<kokkos::impl::impl::viewoffset<> | [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {721}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {714}] 0.03 0.03 1 0 [SAMPLE] reference <unsigned int,="" int,<="" td="" unsigned="" unsith,=""><td>[SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {713}]</td><td>0.03</td><td>3 0.03</td><td>1</td><td>0</td></unsigned> | [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {713}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] reference cunsigned int, unsigned int, unsint, unsigned int, unsigned int, unsigned int, | [SAMPLE] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp} {714}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] unsigned long Kokkos:::Impl::ViewOffset <kokkos:::impl::viewoffset <kokkos:::impl::<="" <kokkos:::impl::viewoffset="" td=""><td>[SAMPLE] reference<unsigned int="" int,="" unsigned=""> [{/g/g20/reeve5/build_v100/install/kokkos/include/impl/Kokkos_ViewMapping.hpp} {2740}]</unsigned></td><td>0.00</td><td>5 0.06</td><td>2</td><td>0</td></kokkos:::impl::viewoffset> | [SAMPLE] reference <unsigned int="" int,="" unsigned=""> [{/g/g20/reeve5/build_v100/install/kokkos/include/impl/Kokkos_ViewMapping.hpp} {2740}]</unsigned> | 0.00 | 5 0.06 | 2 | 0 |
| * [SUMMARY] LAMMPS_RandomVelocityGeom::uniform() [/g/g20/reeve5/pr/CabanaMD/src/input.h] 0.03 0.03 1 0 [SAMPLE] LAMMPS_RandomVelocityGeom::uniform() [/g/g20/reeve5/pr/CabanaMD/src/input.h] {93]] 0.03 0.03 1 0 [Comm::exchange 0.024 0.392 6 3,371 [MPL_Finalize0 Kokkos sample within top-level application code 0.367 0.369 1 68 Comm::exchange_halo 0.022 0.351 6 4,772 [MPL_Init() 0.323 0.323 1 0 [Cohana:Verlet 0.002 0.164 101 606 * [CONTEXT] MP_Allreduce() Instrumented Kokkos::parallel_for 0.002 0.082 39 0 [SAMPLE] _GLsched_yield [{} {0]} 0.03 0.03 1 0 0.03 1 0 [SAMPLE] _GF roceLJCabanaNeigh::compute [device=0] Instrumented Kokkos::parallel_for 0.03 0.03 1 0 [SAMPLE] _GLsched_yield [{} {0]] 0.03 0.03 1 0 0.03 0.03 1 0 [SAMPLE] _GF roceLJCabanaNeigh::compute_energy [device=0] 0.001 0.047 | SAMPLE] unsigned long Kokkos::Impl::ViewOffset <kokkos::impl::viewdimension<0ul, 16ul,="" 3ul="">, Kokkos::LayoutCabanaSlice<176, 16, 3, 0, 0, 0, 0, 0, void></kokkos::impl::viewdimension<0ul,> | | 3 0.03 | 1 | 0 |
| [SAMPLE] LAMMPS_Random/VelocityGeom::uniform() [//g/g20/reeve5/pr/CabanaMD/src/input.h) {93]] 0.03 0.03 0.03 1 0 Comm::exchange 0.024 0.392 6 3,371 MP_Finalize() Kokkos sample within top-level application code 0.365 0.369 1 6 MP_Init() 0.323 0.323 1 0 0.026 0.351 6 4,772 MP_Init() 0.323 0.323 1 0 0.002 0.164 101 606 Cabana:/Verlet 0.002 0.164 101 606 MP_Allreduce() Instrumented Kokkos::parallel_for 0.03 0.03 1 0 SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so) [0] Instrumented Kokkos::parallel_for 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so) [0] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so) [0] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so] [0]] Instrumented Kokkos::par | [SUMMARY] LAMMPS_RandomVelocityGeom::uniform() [{/g/g20/reeve5/pr/CabanaMD/src/input.h}] | 0.03 | 3 0.03 | 1 | 0 |
| □ Comm::exchange 0.024 0.392 6 3,371 □ MP_Finalize0 Kokkos sample within top-level application code 0.367 0.369 1 68 □ Comm::exchange_halo 0.026 0.351 6 4,72 □ MP_Init() 0.323 0.323 1 0 □ Cabana::Verlet 0.004 0.256 6 438 □ Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] 0.002 0.164 101 666 ▼ MP_Allreduce() 0.002 0.164 101 666 ▼ MP_Allreduce() 0.002 0.082 0.082 0.083 0 ▼ SAMPLE]_GL_sched_yield [{} {0}] Instrumented Kokkos::parallel_for 0 0.09 3 0 ■ [SAMPLE]_pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 ■ Kokkos::paralle_for Kokkos::view:initialization [device=0] 0.001 0.072 35 170 ■ Kokkos::paralle_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.001 0.047 10 303 ■ Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energ | [SAMPLE] LAMMPS_RandomVelocityGeom::uniform() [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {93}] | 0.03 | 3 0.03 | 1 | 0 |
| MPI_Finalize() Kokkos sample within top-level application code 0.367 0.369 1 68 Comm::exchange_halo 0.026 0.351 6 4,772 MPI_init() 0.323 0.323 1 0 Cabana::Verlet 0.002 0.164 101 666 Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] 0.002 0.164 101 666 MPI_Allreduce() 0.002 0.164 101 666 MPL_Allreduce() 0.082 0.082 39 0 [SAMPLE]_GI_sched_yield [{} {0}] Instrumented Kokkos::parallel_for 0 0.09 3 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_lock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.001 0.072 35 170 Kokkos::parallel_for Kokos::View::initialization [device=0] 0.001 0.047 101 303 Kokkos::parallel_for Kokos::ViewFill-3D [device=0] 0 0.042 11 77 CudaLaunchKernel 0.01 | Comm::exchange | 0.024 | 4 0.392 | 6 | 3,371 |
| Comm::exchange_halo Kokkos sample within top-level application code 0.026 0.351 6 4,772 MPI_nit() 0.323 0.323 0.323 1 0 Cabana::Verlet 0.004 0.266 6 438 Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] 0.002 0.164 101 606 MPI_Allreduce() 0.002 0.062 0.082 3.99 0 CSAMPLE] pthread_spin_unlock [//usr/lib64/libpthread=2.17.so} {0}] Instrumented Kokkos::parallel_for 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [//usr/lib64/libpthread=2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.001 0.072 35 170 Kokkos::paralle_for Kokkos::View::initialization [device=0] 0.001 0.047 101 303 Kokkos::paralle_for Kokkos::ViewFill-3D [device=0] 0.001 0.047 101 303 Kokkos::parallel_for Kokkos::ViewFill-3D [device=0] 0.015 0.028 527 1,581 | MPL Finalize() Kalkbag gample within top lawal application and | 0.36 | 7 0.369 | 1 | 68 |
| MPI_Init() 0.323 0.323 1 0 Cabana::Verlet 0.004 0.256 6 438 Kokkos::paralle_for ForceL]CabanaNeigh::compute [device=0] 0.002 0.164 101 606 MPI_Allreduce() Instrumented Kokkos::parallel_for 0.082 0.082 39 0 [CONTEXT] MPI_Allreduce() Instrumented Kokkos::parallel_for 0.03 0.03 1 0 [SAMPLE]_cfsched_yield [{ 0] 0.03 0.03 1 0 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [Kokkos::parallel_for Kokkos::View::initialization [device=0] 0.001 0.072 35 170 Kokkos::parallel_reduce ForceL]CabanaNeigh::compute_energy [device=0] 0 0.042 11 777 cudaLaunchKernel 0.015 0.028 527 1,581 | Comm::exchange_halo KOKKOS Sample within top-level application cod | 0.020 | 6 0.351 | 6 | 4,772 |
| Cabana::Verlet 0.004 0.256 6 438 Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] 0.002 0.164 101 606 MPI_Allreduce() 0.082 0.082 39 0 CONTEXT] MPI_Allreduce() 0.03 0.03 1 0 [SAMPLE]_GIsched_yield [{} {0}] 0.03 0.03 1 0 [SAMPLE] phtread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] phtread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] phtread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 1 0 [Kokkos::parallel_for Kokkos::View:initialization [device=0] 0.001 0.072 35 170 [Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.042 11 77 [cudaLaunchKernel 0.015 0.028 527 1,581 | MPL_Init() | 0.323 | 3 0.323 | 1 | 0 |
| Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] 0.002 0.164 101 606 MPI_Allreduce() 0.082 0.082 39 0 [CONTEXT] MPI_Allreduce() 0.082 0.09 3 0 [SAMPLE]_GIsched_yield [{} {0}] 0.03 0.03 1 0 [SAMPLE] phread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.001 0.072 35 170 [Sokkos::parallel_for Kokkos::View:initialization [device=0] 0.01 0.047 101 303 [Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.042 11 77 [cudaLaunchKernel 0.015 0.028 527 1,581 | Cabana::Verlet | 0.004 | 4 0.256 | 6 | 438 |
| MPI_Allreduce() 0.082 0.082 39 0 [CONTEXT] MPI_Allreduce() Instrumented Kokkos::parallel_for 0 0.09 3 0 [SAMPLE]GIsched_yield [{} {0}] 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_lock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [Kokkos::parallel_for Kokkos::View::initialization [device=0] 0.001 0.047 101 303 [Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.015 0.028 527 1,581 | Kokkos::parallel_for ForceLJCabanaNeigh::compute [device=0] | 0.002 | 2 0.164 | 101 | 606 |
| CONTEXT] MPI_Allreduce() Instrumented Kokkos::parallel_for 0 0.09 3 0 [SAMPLE]G[sched_yield [{ 0] [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so { 0] [SAMPLE] pthread_spin_lock [/usr/li | ▼ MPI_Allreduce() | 0.082 | 2 0.082 | 39 | 0 |
| [SAMPLE]GLsched_yield [{} {0}] 0.03 0.03 1 0 [SAMPLE] pthread_spin_unlock [/usr/lib64/libpthread-2.17.so} {0}] 0.03 0.03 1 0 [SAMPLE] pthread_spin_lock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [SAMPLE] pthread_spin_lock [/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel_reduce 0.03 0.03 1 0 [Kokkos::parallel_for Kokkos::View::initialization [device=0] 0.001 0.047 101 303 [Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.042 11 77 [cudaLaunchKernel 0.015 0.028 527 1,581 | ■ [CONTEXT] MPL_Allreduce() Instrumented Kokkos::parallel for | (| 0.09 | 3 | 0 |
| SAMPLE] pthread_spin_unlock [//usr/lib64/libpthread-2.17.so} {0]0.030.0310SAMPLE] pthread_spin_lock [//usr/lib64/libpthread-2.17.so} {0]Instrumented Kokkos::parallel_reduce 0.030.0310Kokkos::parallel_for Kokkos::View::initialization [device=0]0.0010.07235170Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0]00.047101303CudaLaunchKernel0.0150.0285271,581 | [SAMPLE]GIsched_yield [{} {0}] | 0.03 | 3 0.03 | 1 | 0 |
| [SAMPLE] pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}]Instrumented Kokkos::parallel_reduce 0.030.0310Kokkos::parallel_for Kokkos::View::initialization [device=0]0.0010.07235170Kokkos::parallel_for Kokkos::ViewFill-3D [device=0]0.0010.047101303Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0]00.0421177cudaLaunchKernel0.0150.0285271,581 | SAMPLE] pthread_spin_unlock [{/usr/lib64/libpthread-2.17.so} {0}] | _ 0.03 | 3 0.03 | 1 | 0 |
| Kokkos::parallel_for Kokkos::View::initialization [device=0] 0.001 0.072 35 170 Kokkos::parallel_for Kokkos::ViewFill-3D [device=0] 0.001 0.047 101 303 Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.042 11 77 cudaLaunchKernel 0.015 0.028 527 1,581 | [SAMPLE] pthread_spin_lock [{/usr/lib64/libpthread-2.17.so} {0}] Instrumented Kokkos::parallel re | duce 0.03 | 3 0.03 | 1 | 0 |
| Kokkos::parallel_for Kokkos::ViewFill-3D [device=0] 0.001 0.047 101 303 Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] 0 0.042 11 77 cudaLaunchKernel 0.015 0.028 527 1,581 | Kokkos::parallel_for Kokkos::View::initialization [device=0] | 0.00 | 0.072 | 35 | 170 |
| Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0]00.0421177cudaLaunchKernel0.0150.0285271,581 | Kokkos::parallel_for Kokkos::ViewFill-3D [device=0] | 0.00 | 0.047 | 101 | 303 |
| cudaLaunchKernel 0.015 0.028 527 1,581 | Kokkos::parallel_reduce ForceLJCabanaNeigh::compute_energy [device=0] | (| 0.042 | 11 | 77 |
| | cudaLaunchKernel | 0.01 | 5 0.028 | 527 | 1,581 |

Event-based sampling (EBS) with Kokkos API

TAU Execution Command (tau_exec)

Uninstrumented execution % mpirun -np 256 ./a.out Track GPU operations % mpirun –np 256 tau exec –rocm ./a.out ./a.out % mpirun –np 256 tau exec –l0 % mpirun –np 256 tau exec –cupti ./a.out % mpirun –np 256 tau exec –opencl ./a.out % mpirun –np 256 tau exec –openacc ./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,v5,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 export TAU_METRICS=TIME,PAPI_L1_DCM... -ebs_resolution=<file | function | line>

AMD HIP: Kernel execution on GPUs: rochpcg

| • • • TAU: ParaProf: Statistics for: node | 0, thread 6 - rochpcg_amd.ppk | | | |
|---|-------------------------------|----------------------|---------|-------------|
| Name | Exclusive TAUGPU | Inclusive TAUGPU T 🗸 | Calls | Child Calls |
| ▼■.TAU application | 235.631 | . 252.534 | 1 | 500,993 |
| ■void kernel_symgs_sweep<128u>(int, int, int, int, int, int const*, double const*, do | 8.692 | 8.692 | 164,953 | 0 |
| ■void kernel_backward_sweep_0<128u>(int, int, int, int, int const*, double const*, i | r 3.261 | . 3.261 | 109,748 | 0 |
| ■void kernel_forward_sweep_0<128u>(int, int, int, int, int const*, double const*, int | 2.948 | 3 2.948 | 110,058 | 0 |
| ■void kernel_fused_restrict_spmv<1024u>(int, int const*, double const*, int, int, int | ., 0.633 | 0.633 | 11,799 | 0 |
| ■void kernel_waxpby<512u>(int, double, double const*, double, double const*, dou | ł 0.296 | 0.296 | 7,987 | 0 |
| ■void kernel_symgs_halo<128u>(int, int, int, int, int const*, int const*, double cons | t 0.285 | 0.285 | 11,799 | 0 |
| ■void kernel_dot2_part1<256u>(int, double const*, double const*, double*) [clone . | k 0.216 | 0.216 | 7,910 | 0 |
| ■void kernel_fused_waxpby_dot_part1<256u>(int, double, double const*, double*, c | 0.149 | 0.149 | 3,953 | 0 |
| ■void kernel_gather<128u>(int, double const*, int const*, int const*, double*) [clone | e 0.124 | 0.124 | 27,601 | 0 |
| ■void kernel_spmv_halo<128u>(int, int, int, int const*, int const*, double const*, int | t 0.093 | 0.093 | 4,038 | 0 |
| ■void kernel_prolongation<1024u>(int, int const*, double const*, double*, int const | ° 0.077 | 0.077 | 11,775 | 0 |
| void kernel_pointwise_mult<256u>(int, double const*, double const*, double*) [clo | 0.057 | 0.057 | 15,731 | 0 |
| ■void kernel_dot_part2<256u>(double*) [clone .kd] | 0.025 | 0.025 | 7,986 | 0 |
| ■void kernel_fused_waxpby_dot_part2<256u>(int, double*) [clone .kd] | 0.013 | 0.013 | 3,951 | 0 |
| amd_rocclr_copyBuffer.kd | 0.007 | 0.007 | 358 | 0 |
| amd_rocclr_fillBuffer.kd | 0.004 | 0.004 | 120 | 0 |
| ■void kernel_jpl<27u, 16u>(int, int const*, int, int, char const*, int const*, int*) [clo | n 0.00 3 | 0.003 | 16 | 0 |
| void kernel_setup_halo<27u, 16u>(int, int, int, int, int, int, int, bool, bool, bool, int | . 0.002 | 0.002 | 4 | 0 |
| ■void kernel_to_ell_val<27u, 32u>(int, int, double const*, double*) [clone .kd] | 0.002 | 0.002 | 4 | 0 |
| ■void kernel_perm_cols<32u, 16u>(int, int, int, int const*, int*, double*) [clone .kd] | 0.002 | 0.002 | 4 | 0 |
| ■void kernel_generate_problem<27u, 16u>(int, int, int, int, int, long long, long long | , 0.002 | 0.002 | 4 | 0 |
| void kernel_permute_ell_rows<1024u>(int, int, int const*, double const*, int const | * 0.002 | 0.002 | 108 | 0 |
| void kernel_dot1_part1<256u>(int, double const*, double*) [clone .kd] | 0.002 | 0.002 | 83 | 0 |
| ■void rocprim::detail::sort_and_scatter_kernel<256u, 15u, 6u, false, long long*, long | g 0.001 | . 0.001 | 72 | 0 |
| void kernel_to_ell_col<27u, 32u>(int, int, int const*, int*, int*, int*) [clone .kd] | 0.001 | . 0.001 | 4 | 0 |
| ■void rocprim::detail::sort_and_scatter_kernel<256u, 15u, 7u, false, long long*, long | g 0.001 | . 0.001 | 48 | 0 |
| ■void rocprim::detail::sort_and_scatter_kernel<256u, 17u, 6u, false, int*, int*, rocpr | i 0.001 | . 0.001 | 48 | 0 |



Intel Level Zero (TigerLake Gen12LP integrated CPUs or DG1)

| | TAU: ParaProf: Statistics for: node 0, three | ad 0 - ze_gemm_4096.ppk | | | ••• | TAU: ParaProf: Statis | stics for: node 0, thread 2 - ze_gemm_4096. | .ppk | | |
|--|--|-------------------------|----------|-------------|---|-----------------------|---|-------|---------|------------------|
| | Evelucius TAUCOULT | | C - ll - | Child Calls | | | Fuchasias TAU | | Calla C | |
| Name | Exclusive TAUGPU_1 | | Calls | Child Calls | TALL application | Name | Exclusive TAU | | | niid Calls 24 |
| | 20 877 063 | 20,877,063 | 1 | 250 | -Rarrier> | | 0.151 | 25.00 | 8 | - 1 |
| ICONTEXT] zeCommandQueueSynchronize | 25,077,503 | 29,077,505 | 997 | 0 | <pre></pre> <pre></pre> <pre></pre> <pre></pre> | | 0.049 | 0.049 | 12 | 0 |
| [SAMPLE] CL sched vield [{/lib64/libc-2.26.so} | 25 765 719 | 25,505,000 | 859 | 0 | GEMM | | 29.7 | 29.7 | 4 | 0 |
| SAMPLE] UNRESOLVED /soft/libraries/intel-level-z | 4,139,969 | 4,139,969 | 138 | 0 | | | | | | - |
| ZeCommandOueueExecuteCommandLists | 186.203 | 186.203 | 4 | 0 | | | | | | |
| zeModuleCreate | 98,896 | 98,896 | 1 | 0 | | | | | | |
| zeCommandListAppendMemoryCopy | 1,410 | 1,410 | 12 | 0 | | | | | | |
| zeCommandQueueDestroy | 321 | . 321 | 4 | 0 | | | | | | |
| ■ zeDriverAllocDeviceMem | 137 | 137 | 12 | 0 | | | Linita, acar | ada | | |
| zeEventPoolDestroy | 128 | 128 | 20 | 0 | | | Units: secor | las | | |
| zeDriverFreeMem | 96 | 96 | 12 | 0 | | | | | | |
| zeCommandListCreate | 89 | 89 | 4 | 0 | | | | | | |
| zeCommandQueueCreate | 82 | 82 | 4 | 0 | | - | · · · · · · | | | |
| zeCommandListDestroy | 71 | . 71 | 4 | 0 | | Lime spent in GE | -MM kernel | | | |
| zeKernelSetArgumentValue | 43 | 43 | 16 | 0 | | • | | | | |
| zeDeviceGetProperties | 38 | 38 | 26 | 0 | | | | | | |
| zeCommandListClose | 35 | 35 | 4 | 0 | | | | | | |
| zeEventCreate | 30 | 30 | 4 | 0 | | | | | | |
| zeEventDestroy | 30 | 30 | 24 | 0 | | | | | | |
| zeEventGetTimestamp | 28 | 28 | 48 | 0 | | | | | | |
| pthread_create | 26 | 26 | 1 | 0 | | | | | | |
| zeEventPoolCreate | 20 | 20 | 4 | 0 | | | | | | |
| zeKernelDestroy | 20 | 20 | 1 | 0 | | | | | | |
| zeModuleDestroy | 17 | , 17 | 1 | 0 | | | | | | |
| zeCommandListAppendLaunchKernel | 15 | 15 | 4 | 0 | | | | | | |
| zeCommandListAppendBarrier | 13 | 13 | 8 | 0 | | | | | | |
| zeKernelSuggestGroupSize | 12 | 12 | 4 | 0 | | | | | | |
| zeEventQueryStatus | 11 | . 11 | 20 | 0 | | | | | | |
| zeKernelCreate | 11 | . 11 | 1 | 0 | | | | | | |
| zeKernelSetGroupSize | 5 | 5 | 4 | 0 | | | | | | |
| zeDeviceGet | 2 | 2 | 2 | 0 | | | | | | |
| zelnit | 2 | 2 | 1 | 0 | | | | | | |
| ■ zeDriverGet | C | 0 | 2 | 0 | | | | | | |

Units: microseconds



CUPTI (CUDA Profiling Tools Interface)

| TAU: ParaProf: Statistics for: node 0, thread 0 - exafel1_230cores.ppk | | | | |
|---|---------------|----------|-------|-------------|
| | | | | |
| Name | Exclusive ⊽ I | nclusive | Calls | Child Calls |
| Image: Second | 20.036 | 20.362 | 303 | 10,914 |
| run_sim2smv [{step5_pad.py}{138}] | 16.78 | 134.9 | 1 | 1,066 |
| Init_ [{initpy}{150}] | 11.669 | 15.909 | 101 | 1,010 |
| Channel_pixels [{step5_pad.py}{79}] | 11.029 | 107.657 | 100 | 13,358 |
| [CONTEXT] channel_pixels [{step5_pad.py}{79}] | 0 | 9.345 | 312 | 0 |
| [SAMPLE] nanoBraggSpotsCUDA [{/autofs/nccs-svm1_home1/iris/adse13_161/psana-legion/simtbx/sun | r 4.755 | 4.755 | 159 | 0 |
| [SAMPLE] simtbx::nanoBragg::nanoBragg::add_nanoBragg_spots_cuda() [{/autofs/nccs-svm1_home1/iris, | 4.08 | 4.08 | 136 | 0 |
| [SAMPLE]memset_power8 [{} {0}] | 0.3 | 0.3 | 10 | 0 |
| [SAMPLE] UNRESOLVED /usr/lib64/libc-2.17.so | 0.181 | 0.181 | 6 | 0 |
| SUMMARY] Tau_handle_driver_api_memcpy(void*, CUpti_CallbackDomain, unsigned int, CUpti_CallbackData | 0.03 | 0.03 | 1 | 0 |
| ▶ □ cuMemcpyDtoH_v2 | 9.483 | 9.483 | 500 | 0 |
| expand_to_p1_iselection [{initpy}{1376}] | 7.349 | 7.35 | 101 | 606 |
| ▶ ■ load | 7.004 | 7.009 | 2 | 2,251 |
| reset_wavelength [{util_fmodel.py}{121}] | 6.197 | 6.553 | 100 | 47,550 |
| is_unique_set_under_symmetry [{initpy}{790}] | 5.913 | 5.915 | 202 | 808 |
| ▶ ■import | 5.782 | 15.766 | 382 | 78 |
| fdp_fdp_at_wavelength [{fdp_plot.py}{44}] | 5.616 | 5.723 | 800 | 1,600 |
| MPI_Init_thread() | 4.987 | 4.987 | 1 | 0 |
| uDevicePrimaryCtxRetain | 4.735 | 4.735 | 2 | 0 |
| ▶ | 4.255 | 23.888 | 85 | 756 |
| MPI_Finalize() | 3.829 | 3.829 | 1 | 1 |
| match_bijvoet_mates [{initpy}{1032}] | 3.146 | 3.684 | 101 | 707 |
| ▶ ■ bcast | 3.073 | 3.448 | 1 | 9 |
| ▶ ■init [{initpy}{20}] | 3.011 | 3.399 | 101 | 149,196 |
| Compute_f_mask [{initpy}{299}] | 2.897 | 18.853 | 101 | 707 |

Python, MPI, CUDA, and samples from DSOs are all integrated in a single view % mpirun –np 64 tau_python –cupti ./exafel.py

TAU supports Python, MPI, and CUDA

Without any modification to the source code or DSOs or interpreter, it instruments and samples the application using Python, MPI, and CUDA instrumentation.

| | TAU: ParaProf: Statistics for: node 0, thread 2 - exafel1_230cores.ppk | | | | | | | |
|-----------|--|-----------|-------------|-------|-------------|--|--|--|
| | | | | | | | | |
| | Name 🗠 | Exclusive | Inclusive I | Calls | Child Calls | | | |
| | .TAU application | 79.623 | 89.93 | 1 | 2,480 | | | |
| | Memory copy Device to Host | 8.216 | 8.216 | 425 | 0 | | | |
| | Memory copy Host to Device | 0.807 | 0.807 | 1,970 | 0 | | | |
| | nanoBraggSpotsCUDAKernel(int, int, int, int, int, | 1.284 | 1.284 | 85 | 0 | | | |
| Kernel on | GPU | | | | | | | |

% mpirun –np 230 tau_python –T cupti,mpi,pdt –ebs –cupti ./exafel.py Instead of:

% mpirun -np 230 python ./exafel.py



Deep Learning: Tensorflow

EXASCALE

| TAU: ParaProf: Statistics for: node 0, thread 8 - nt3_baseline_keras2.ppk | | |
|--|----------|--------|
| | | |
| Name | Inclusiv | |
| | 519.211 | 1 |
| [CONTEXT] . TAU application | 509.222 | 50,915 |
| [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<="" td=""><td>51.345</td><td>5,135</td></float,> | 51.345 | 5,135 |
| [SAMPLE] Eigen::internal::gemm_pack_rhs <float, eigen::internal::tensorcontractionsubmapper<="" eigen::internal::tensorcontractionsubmapper<float,="" long,="" 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> co</eigen::tensorcontractionop<eigen::array<eigen::indexpair<long> | 5.99 | 599 |
| [SAMPLE] long Eigen::internal::operator/ <long, false="">(long const&, Eigen::internal::TensorIntDivisor<long, false)<="" p=""></long,></long,> | 5.843 | 585 |
| [SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<i<="" long),="" p=""></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> 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, eigen::internal::tensorcontractionsubmapper<float,="" lon<="" long,="" p=""></float,> | 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<i<="" long),="" p=""></void> | 2.91 | 291 |
| [SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<i<="" long),="" p=""></void> | 2.772 | 277 |
| [SAMPLE] Eigen::internal::gemm_pack_lhs < float, long, Eigen::internal::TensorContractionSubMapper < float, lon | 2.481 | 248 |
| [SAMPLE] std::_Function_handler <void (long,="" eigen::internal::tensorexecutor<eigen::tensorassignop<i<="" long),="" p=""></void> | 2.148 | 215 |
| [SAMPLE] void Eigen::internal::call_dense_assignment_loop <eigen::map<eigen::matrix<float, -1,="" -1<="" 0,="" p=""></eigen::map<eigen::matrix<float,> | 2.008 | 197 |
| [SAMPLE] Eigen::NonBlockingThreadPoolTempl <tensorflow::thread::eigenenvironment>::WorkerLoop(int) [{/ho</tensorflow::thread::eigenenvironment> | 1.999 | 200 |
| [SAMPLE] Eigen::internal::ptranspose(Eigen::internal::PacketBlock <floatvector, 4="">&) [{crtstuff.c} {0}]</floatvector,> | 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> co</eigen::tensorcontractionop<eigen::array<eigen::indexpair<long> | 1.518 | 152 |

% tau_python -ebs nt3_baseline_keras2.py

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MPI Tools Interface: PVARs and CVARs

| TAU: ParaProf: Context Events for: node 2, thread 0 - comb_mpit_ebs.ppk | | | | | | |
|--|---------|------------|----------|----------|-----------|-----------|
| Name 🗠 | Total | NumSamples | MaxValue | MinValue | MeanValue | Std. Dev. |
| Message size for broadcast | 4 | 1 | 4 | 4 | 4 | 0 |
| Message size for reduce | 608 | 20 | 48 | 8 | 30.4 | 15.513 |
| mpit_progress_poll (CH3 RDMA progress engine polling count) | 474,499 | 1 | 474,499 | 474,499 | 474,499 | 0 |
| mv2_coll_allgather_bytes_recv (Number of bytes recv by default algorithm of allgathe | 612 | 1 | 612 | 612 | 612 | 0 |
| mv2_coll_allgather_bytes_send (Number of bytes send by default algorithm of allgath | 252 | 1 | 252 | 252 | 252 | 0 |
| mv2_coll_allgather_count_recv (Count of messages recv by default algorithm of allgat | 21 | 1 | 21 | 21 | 21 | 0 |
| mv2_coll_allgather_count_send (Count of messages send by default algorithm of allga | 21 | 1 | 21 | 21 | 21 | 0 |
| mv2_coll_allgather_rd (Number of times recursive doubling Allgather was invoked) | 7 | 1 | 7 | 7 | 7 | 0 |
| mv2_coll_allgather_rd_bytes_recv (Number of bytes recv by rd algorithm of allgather | 612 | 1 | 612 | 612 | 612 | 0 |
| mv2_coll_allgather_rd_bytes_send (Number of bytes send by rd algorithm of allgather | 252 | 1 | 252 | 252 | 252 | 0 |
| mv2_coll_allgather_rd_count_recv (Count of messages recv by rd algorithm of allgath | 21 | 1 | 21 | 21 | 21 | 0 |
| mv2_coll_allgather_rd_count_send (Count of messages send by rd algorithm of allgat | 21 | 1 | 21 | 21 | 21 | 0 |
| mv2_coll_allreduce_2lvl (Number of times MV2 two-level allreduce algorithm was invo | 5 | 1 | 5 | 5 | 5 | 0 |
| mv2_coll_allreduce_bytes_recv (Number of bytes recv by allreduce collective) | 7,080 | 1 | 7,080 | 7,080 | 7,080 | 0 |
| mv2_coll_allreduce_bytes_send (Number of bytes send by allreduce collective) | | 1 | 7,080 | 7,080 | 7,080 | 0 |
| mv2_coll_allreduce_count_recv (Count of messages recv by allreduce collective) | | 1 | 42 | 42 | 42 | 0 |
| mv2_coll_allreduce_count_send (Count of messages send by allreduce collective) | 42 | 1 | 42 | 42 | 42 | 0 |
| mv2_coll_allreduce_pt2pt_rd_bytes_recv (Number of bytes recv by pt2pt rd algorithm | 7,080 | 1 | 7,080 | 7,080 | 7,080 | 0 |
| mv2_coll_allreduce_pt2pt_rd_bytes_send (Number of bytes send by pt2pt rd algorithn | 7,080 | 1 | 7,080 | 7,080 | 7,080 | 0 |
| mv2_coll_allreduce_pt2pt_rd_count_recv (Count of messages recv by pt2pt rd algorith | 42 | 1 | 42 | 42 | 42 | 0 |
| mv2_coll_allreduce_pt2pt_rd_count_send (Count of messages send by pt2pt rd algorit | 42 | 1 | 42 | 42 | 42 | 0 |
| mv2_coll_allreduce_shm_intra (Number of times MV2 shm intra allreduce algorithm w | 3 | 1 | 3 | 3 | 3 | 0 |
| mv2_coll_allreduce_shm_rd (Number of times MV2 shm rd allreduce algorithm was in | 14 | 1 | 14 | 14 | 14 | 0 |
| mv2_coll_allreduce_subcomm (Number of times MV2 allreduce was invoked at a sub- | 10 | 1 | 10 | 10 | 10 | 0 |
| mv2_coll_barrier_count_recv (Count of messages recv by barrier collective) | 24 | 1 | 24 | 24 | 24 | 0 |
| mv2_coll_barrier_count_send (Count of messages send by barrier collective) | 24 | 1 | 24 | 24 | 24 | 0 |
| mv2_coll_barrier_pairwise (Number of times pairwise barrier was invoked) | 8 | 1 | 8 | 8 | 8 | 0 |
| mv2_coll_barrier_pairwise_count_recv (Count of messages recv by pairwise algorithm | 24 | 1 | 24 | 24 | 24 | 0 |
| mv2_coll_barrier_pairwise_count_send (Count of messages send by pairwise algorithr | 24 | 1 | 24 | 24 | 24 | 0 |

% export TAU_TRACK_MPI_T_PVARS=1
% mpirun -np 64 tau_exec -T mpit ./a.out



MPI Tools Interface: Control Variables (CVARs)

| TAU: ParaProf Manager | | | | | |
|---------------------------|--|--|--|--|--|
| Applications | TrialField | Value | | | |
| 🔻 🖿 Standard Applications | Name | comb_mpit_ebs.ppk | | | |
| 🔻 💳 Default App | Application ID | 0 | | | |
| 🔻 💳 Default Exp | Experiment ID | 0 | | | |
| comb_mpit_ebs.ppk | Trial ID | 0 | | | |
| TIME | CPU Cores | 24 | | | |
| | CPU MHz | 2000.000 | | | |
| | СРИ Туре | AMD EPYC 7401 24-Core Processor | | | |
| | CPU Vendor | AuthenticAMD | | | |
| | CWD | /usr/global/tools/tau/training/apps/COMB_LLNL/Comb/build_lc_toss3_gcc_8_3_1/bin | | | |
| | Cache Size | 512 KB | | | |
| | Command Line | ./comb -comm post_recv wait_all -comm post_send wait_all -comm wait_recv wait_all -comm wait_send wait_all 200_200_20 | | | |
| | Ending Timestamp | 1612559352834401 | | | |
| | Executable | /usr/global/tools/tau/training/apps/COMB_LLNL/Comb/build_lc_toss3_gcc_8_3_1/bin/comb | | | |
| | File Type Index | 0 | | | |
| | File Type Name | ParaProf Packed Profile | | | |
| | Hostname | corona107 | | | |
| | Local Time | 2021-02-05T13:09:08-08:00 | | | |
| | MPI Processor Name | corona107 | | | |
| | MPI_T CVAR: MPIR_CVAR_ABORT_ON_LEAKED_HANDLES | If true, MPI will call MPI_Abort at MPI_Finalize if any MPI object handles have been leaked. For example, if MPI_Comm_dup is c | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLGATHERV_PIPELINE_MSG_SIZE | The smallest message size that will be used for the pipelined, large-message, ring algorithm in the MPI_Allgatherv implement | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLGATHER_COLLECTIVE_ALGORITHM | This CVAR selects proper collective algorithm for allgather operation. | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLGATHER_LONG_MSG_SIZE | For MPI_Allgather and MPI_Allgatherv, the long message algorithm will be used if the send buffer size is $>$ = this value (in byte | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLGATHER_SHORT_MSG_SIZE | For MPI_Allgather and MPI_Allgatherv, the short message algorithm will be used if the send buffer size is $<$ this value (in bytes | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLREDUCE_COLLECTIVE_ALGORITHM | This CVAR selects proper collective algorithm for allreduce operation. | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLREDUCE_SHORT_MSG_SIZE | the short message algorithm will be used if the send buffer size is $<=$ this value (in bytes) | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLTOALLV_COLLECTIVE_ALGORITHM | This CVAR selects proper collective algorithm for alltoally operation. | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLTOALL_COLLECTIVE_ALGORITHM | This CVAR selects proper collective algorithm for alltoall operation. | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLTOALL_MEDIUM_MSG_SIZE | the medium message algorithm will be used if the per-destination message size (sendcount*size(sendtype)) is \leq this value a | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLTOALL_SHORT_MSG_SIZE | the short message algorithm will be used if the per-destination message size (sendcount*size(sendtype)) is \leq this value (See | | | |
| | MPI_T CVAR: MPIR_CVAR_ALLTOALL_THROTTLE | max no. of irecvs/isends posted at a time in some alltoall algorithms. Setting it to 0 causes all irecvs/isends to be posted at o | | | |
| | MPI_T CVAR: MPIR_CVAR_ASYNC_PROGRESS | If set to true, MPICH will initiate an additional thread to make asynchronous progress on all communication operations includi | | | |
| | MPI_T CVAR: MPIR_CVAR_BCAST_COLLECTIVE_ALGORITHM | This CVAR selects proper collective algorithm for broadcast operation. | | | |
| | MPI_T CVAR: MPIR_CVAR_BCAST_LONG_MSG_SIZE | Let's define short messages as messages with size < MPIR_CVAR_BCAST_SHORT_MSG_SIZE, and medium messages as message | | | |
| | MPI_T CVAR: MPIR_CVAR_BCAST_MIN_PROCS | Let's define short messages as messages with size < MPIR_CVAR_BCAST_SHORT_MSG_SIZE, and medium messages as message | | | |
| | MPI_I CVAR: MPIR_CVAR_BCAST_SHORT_MSG_SIZE | Let's define short messages as messages with size < MPIR_CVAR_BCAST_SHORT_MSG_SIZE, and medium messages as message | | | |
| | MPI_I CVAR: MPIR_CVAR_CH3_EAGER_MAX_MSG_SIZE | I his cvar controls the message size at which CH3 switches from eager to rendezvous mode. | | | |
| | MPI_I CVAR: MPIR_CVAR_CH3_ENABLE_HCOLL | If true, enable HCOLL collectives. | | | |
| | MPI_T CVAR: MPIR_CVAR_CH3_INTERFACE_HOSTNAME | It non-NULL, this cvar specifies the IP address that other processes should use when connecting to this process. This cvar is m | | | |
| | MPI_T CVAR: MPIR_CVAR_CH3_NOLOCAL | If true, force all processes to operate as though all processes are located on another node. For example, this disables shared | | | |



MPI Tools Interface: Performance Variables (PVARs)

| | | TAU: ParaProf Manager |
|----------------------------------|---|--|
| Applications | TrialField | Value |
| Standard Applications | MPI_T CVAR: MPIR_CVAR_USE_CUDA | This option enables the CUDA library. |
| 🔻 🖿 Default App | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT | This option enables use of GPUDIRECT in CUDA library. |
| 🔻 🖿 Default Exp | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT_GDRCOPY | This option enables use of GPUDIRECT_GDRCOPY in CUDA library. |
| comb_mpit_ebs.ppk | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT_GDRCOPY_LIMIT | This option sets limit on Gpudirect GDRCOPY in CUDA library. |
| TIME | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT_LOOPBACK | This option enables use of GPUDIRECT_LOOPBACK in CUDA library. |
| | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT_LOOPBACK_LIMIT | This option sets limit on GPUDIRECT LOOPBACK in CUDA library. |
| | MPI_T CVAR: MPIR_CVAR_USE_GPUDIRECT_RECEIVE_LIMIT | This option sets limit on MV2_USE_GPUDIRECT_RECEIVE_LIMIT in CUDA library. |
| | MPI_T CVAR: MPIR_CVAR_USE_IWARP_MODE | This parameter enables the library to run in iWARP mode. |
| | MPI_T CVAR: MPIR_CVAR_USE_MCAST | Set this to 1, to enable hardware multicast support in collective communication. |
| | MPI_T CVAR: MPIR_CVAR_USE_RDMA_CM | This parameter enables the use of RDMA CM for establishing the connections. |
| | MPI_T CVAR: MPIR_CVAR_USE_SHARED_MEM | Use shared memory for intra-node communication. |
| | MPI_T PVAR[0]: mv2_pt2pt_mpid_send | bucket level counters for mpid send |
| | MPI_T PVAR[100]: mv2_coll_timer_alltoall_rd | total time spent on the MV2 alltoall_rd algorithm |
| | MPI_T PVAR[101]: mv2_coll_timer_alltoall_rd | total time spent on the MV2 alltoall_rd algorithm |
| | MPI_T PVAR[102]: mv2_coll_timer_alltoall_sd | total time spent on the MV2 alltoall_sd algorithm |
| | MPI_T PVAR[103]: mv2_coll_timer_alltoall_sd | total time spent on the MV2 alltoall_sd algorithm |
| | MPI_T PVAR[104]: mv2_coll_timer_alltoall_pw | total time spent on the MV2 alltoall_pw algorithm |
| | MPI_T PVAR[105]: mv2_coll_timer_alltoall_pw | total time spent on the MV2 alltoall_pw algorithm |
| | MPI_T PVAR[106]: mv2_coll_alltoall_inplace | Number of times MV2 in-place alltoall algorithm was invoked |
| | MPI_T PVAR[107]: mv2_coll_alltoall_bruck | Number of times MV2 brucks alltoall algorithm was invoked |
| | MPI_T PVAR[108]: mv2_coll_alltoall_rd | Number of times MV2 recursive-doubling alltoall algorithm was invoked |
| | MPI_T PVAR[109]: mv2_coll_alltoall_sd | Number of times MV2 scatter-destination alltoall algorithm was invoked |
| | MPI_T PVAR[10]: mv2_smp_read_progress_poll_success | Unsuccessful CH3 SMP read progress engine polling count |
| | MPI_T PVAR[110]: mv2_coll_alltoall_pw | Number of times MV2 pairwise alltoall algorithm was invoked |
| | MPI_T PVAR[111]: mv2_coll_alltoall_inplace_bytes_send | Number of bytes send by inplace algorithm of alltoall collective |
| | MPI_T PVAR[112]: mv2_coll_alltoall_bruck_bytes_send | Number of bytes send by bruck algorithm of alltoall collective |
| | MPI_T PVAR[113]: mv2_coll_alltoall_sd_bytes_send | Number of bytes send by sd algorithm of alltoall collective |
| | MPI_T PVAR[114]: mv2_coll_alltoall_pw_bytes_send | Number of bytes send by pw algorithm of alltoall collective |
| | MPI_T PVAR[115]: mv2_coll_alltoall_inplace_bytes_recv | Number of bytes recv by inplace algorithm of alltoall collective |
| | MPI_T PVAR[116]: mv2_coll_alltoall_bruck_bytes_recv | Number of bytes recv by bruck algorithm of alltoall collective |
| | MPI_T PVAR[117]: mv2_coll_alltoall_sd_bytes_recv | Number of bytes recv by sd algorithm of alltoall collective |
| | MPI_T PVAR[118]: mv2_coll_alltoall_pw_bytes_recv | Number of bytes recv by pw algorithm of alltoall collective |
| | MPI_T PVAR[119]: mv2_coll_alltoall_inplace_count_send | Count of messages send by inplace algorithm of alltoall collective |
| | MPI_T PVAR[11]: mv2_smp_write_progress_poll_success | Unsuccessful CH3 SMP write progress engine polling count |
| | MPI_T PVAR[120]: mv2_coll_alltoall_bruck_count_send | Count of messages send by bruck algorithm of alltoall collective |
| | MPI_T PVAR[121]: mv2_coll_alltoall_sd_count_send | Count of messages send by sd algorithm of alltoall collective |
| | MPI_T PVAR[122]: mv2_coll_alltoall_pw_count_send | Count of messages send by pw algorithm of alltoall collective |
| | MPI_T PVAR[123]: mv2_coll_alltoall_inplace_count_recv | Count of messages recv by inplace algorithm of alltoall collective |
| | MPI_T PVAR[124]: mv2_coll_alltoall_bruck_count_recv | Count of messages recv by bruck algorithm of alltoall collective |



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 no callpath or routine i | | 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 | | Setting to 1 generate debugging callstack info when a program crashes | |
| TAU_COMM_MATRIX | 0 | Setting to 1 generates communication matrix display using context events | |
| TAU_THROTTLE 1 | | Setting to 0 turns off throttling. Throttles instrumentation in lightweight routines that are called frequently | |
| TAU_THROTTLE_NUMCALLS | 100000 | Specifies the number of calls before testing for throttling | |
| TAU_THROTTLE_PERCALL | 10 | Specifies value in microseconds. Throttle a routine if it is called over 100000 times and takes less than 10 usec of inclusive time per call | |
| TAU_CALLSITE | 0 | Setting to 1 enables callsite profiling that shows where an instrumented function was called. Also compatible with tracing. | |
| TAU_PROFILE_FORMAT | Profile | Setting to "merged" generates a single file. "snapshot" generates xml format | |
| TAU_METRICS | TIME | Setting to a comma separated list generates other metrics. (e.g., ENERGY,TIME,P_VIRTUAL_TIME,PAPI_FP_INS,PAPI_NATIVE_ <event>:<subevent>)</subevent></event> | |



Runtime Environment Variables

| Environment Variable Default | | Description | | | |
|----------------------------------|---------------------------------|--|--|--|--|
| TAU_TRACE | 0 Setting to 1 turns on tracing | | | | |
| TAU_TRACE_FORMAT | Default | Setting to "otf2" turns on TAU's native OTF2 trace generation (configure with –otf=download) | | | |
| TAU_EBS_UNWIND | 0 | Setting to 1 turns on unwinding the callstack during sampling (use with tau_exec –ebs or TAU_SAMPLING=1) | | | |
| TAU_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. | | | |



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_EVENT_THRESHOLD | 0.5 | Define a threshold value (e.g., .25 is 25%) to trigger marker events for min/max | | |



Download TAU from U. Oregon



https://e4s.io [TAU in Docker/Singularity containers]

for more information

Free download, open source, BSD license



Performance Research Laboratory, University of Oregon, Eugene









www.uoregon.edu

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