Multi-Level Performance Instrumentation for Kokkos Applications using TAU

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Slides:
http://tau.uoregon.edu/TAU_Kokkos_SC19.pdf

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Motivation: Kokkos https://github.com/kokkos/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
- This talk: experience extending TAU to support Kokkos

TAU Performance System®

- **Tuning and Analysis Utilities (20+ year project)**
- **Comprehensive performance profiling and tracing**
  - Integrated, scalable, flexible, portable
  - Targets all parallel programming/execution paradigms
- **Integrated performance toolkit**
  - Instrumentation, measurement, analysis, visualization
  - Widely-ported performance profiling / tracing system
  - Performance data management and data mining
  - Open source (BSD-style license)
- **Easy to integrate in application frameworks**
- ***http://tau.uoregon.edu***

Understanding Application Performance using TAU

- **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?
- **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 extent of data transfer** between host and a GPU? In an Kokkos, OpenMP, OpenCL program.
- **What is the contribution of each *phase*** of the program? What is the time wasted/spent waiting for collectives, and I/O operations in Initialization, Computation, I/O phases?
- **How does the application *scale***? What is the efficiency, runtime breakdown of performance across different core counts?

Types of Performance Profiles

Flat **profiles**

- Metric (e.g., time) spent in an event
- Exclusive/inclusive, # of calls, child calls, …

Callpath **profiles**

- Time spent along a calling path (edges in callgraph)
- *"main=> f1 => f2 => MPI_Send"*
- Set the TAU_CALLPATH and TAU_CALLPATH_DEPTH environment variables

Callsite **profiles**

- Time spent along in an event at a given source location
- Set the TAU_CALLSITE environment variable

Phase **profiles**

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

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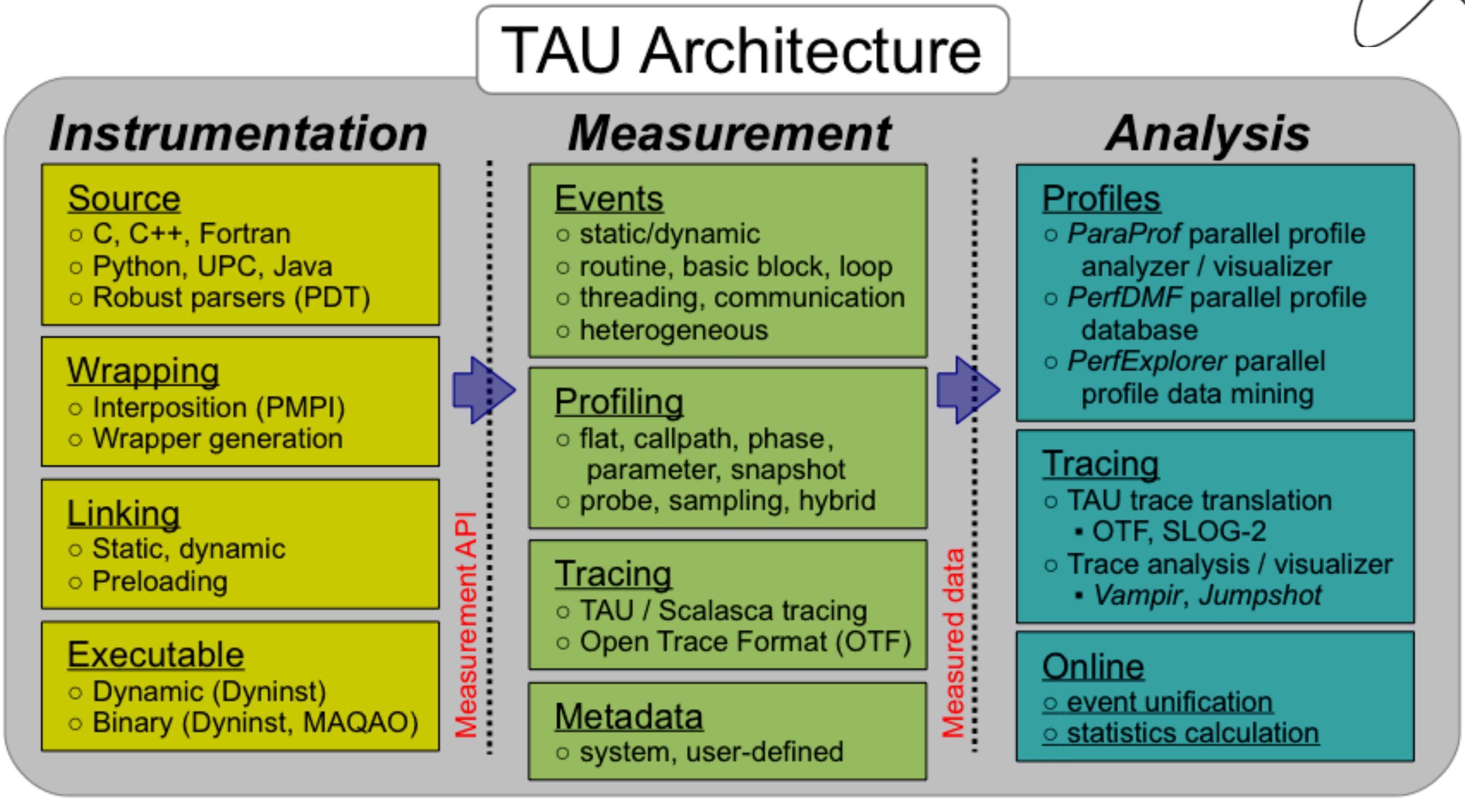
Kokkos Profiling Interface

```
extern "C" void kokkosp_init_library(…);
extern "C" void kokkosp_finalize_library();
extern "C" void kokkosp_begin_parallel_for(const char* name,…);
extern "C" void kokkosp_begin_parallel_reduce(const char* name, …);
extern "C" void kokkosp_begin_parallel_scan(const char* name, …);
/* corresponding end parallel constructs */
extern "C" void kokkosp_push_profile_region(const char* name);
extern "C" void kokkosp_pop_profile_region();
… /* other APIs for sections, data transfers, memory allocation, …*/
```

TAU

- Tracks kernel names specified as the first parameter in parallel API
- When name is not specified, TAU uses the template instantiation
- TAU needs to demangle mangled names of C++ entities
- TAU maps Kokkos profiling regions to TAU phases
- In a TAU phase, all functions called directly/indirectly are flattened into a flat profile under the phase
- Other runtime system calls (CUDA, Pthread, OpenMP) are also tracked alongside Kokkos calls
- Multi-level instrumentation support in TAU can help us slice through multiple runtime layers

TAU Architecture and Workflow



TAU's Support for Runtime Systems

MPI

- PMPI profiling interface
- MPI_T tools interface using performance and control variables

Kokkos

- Kokkos profiling API
- Push/pop interface for region, kernel execution interface

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

TAU's Support for Runtime Systems (contd.)

OpenCL

- OpenCL profiling interface
- Track timings of kernels

OpenACC

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

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

Python

- Python interpreter instrumentation API
- Tracks Python routine transitions as well as Python to C transitions

Examples of Multi-Level Instrumentation

MPI + OpenMP

- MPI_T + PMPI + OMPT may be used to track MPI and OpenMP

MPI + CUDA

- PMPI + CUPTI interfaces

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

- Python + CUPTI + pthread profiling interfaces (e.g., Tensorflow, PyTorch)

MPI + OpenCL

- PMPI + OpenCL profiling interfaces

Simplifying the use of TAU!

Uninstrumented code:

- % make
- % mpirun –np 256 ./a.out

With TAU using event based sampling (EBS):

- % mpirun –np 256 tau_exec –ebs ./lu.B.64
- % paraprof   (GUI)
- % pprof –a | more

NOTE:

- Requires dynamic executables (-dynamic link flag on Cray XC systems).
- Source code should be compiled with –g for access to symbol table.
- Kokkos support is on by default in tau_exec

TAU Execution Command (tau_exec)

Uninstrumented execution

- % mpirun -np 256 ./a.out

Track GPU operations

- % mpirun –np 256 tau_exec –rocm ./a.out
- % mpirun –np 256 tau_exec –cupti ./a.out
- % mpirun –np 256 tau_exec –opencl ./a.out
- % mpirun –np 256 tau_exec –openacc ./a.out

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)

- % export TAU_OMPT_SUPPORT_LEVEL=full;
  % mpirun −np 256 tau_exec −T openmp,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 -ebs_source=<PAPI_COUNTER> -ebs_period=<overflow_count>
  -ebs_resolution=<file | function | line>

Kokkos API use in ExaMiniMD

20. sameer@pegasus:~/pkgs/ORNL/DEMO/BUILD/ExaMiniMD-pthread/ExaMiniMD/src/comm_types (ssh)

```
void CommMPI::update_halo() {

  Kokkos::Profiling::pushRegion("Comm::update_halo");

  N_ghost = 0;
  s=*system;

  pack_buffer_update = t_buffer_update((T_X_FLOAT*)pack_buffer.data(),pack_indicies_all.extent(1));
  unpack_buffer_update = t_buffer_update((T_X_FLOAT*)unpack_buffer.data(),pack_indicies_all.extent(1));

  for(phase = 0; phase<6; phase++) {
    pack_indicies = Kokkos::subview(pack_indicies_all,phase,Kokkos::ALL());
    if(proc_grid[phase/2]>1) {

      Kokkos::parallel_for("CommMPI::halo_update_pack",
         Kokkos::RangePolicy<TagHaloUpdatePack, Kokkos::IndexType<T_INT> >(0,proc_num_send[phase]),
         *this);
      MPI_Request request;
      MPI_Status status;
      MPI_Irecv(unpack_buffer.data(),proc_num_recv[phase]*sizeof(T_X_FLOAT)*3/sizeof(int),MPI_INT, proc_neighbors_recv[phase],100002,MPI_COMM_WORLD,&request);
      MPI_Send (pack_buffer.data(),proc_num_send[phase]*sizeof(T_X_FLOAT)*3/sizeof(int),MPI_INT, proc_neighbors_send[phase],100002,MPI_COMM_WORLD);
      s = *system;
      MPI_Wait(&request,&status);
      const int count = proc_num_recv[phase];
      if(unpack_buffer_update.extent(0)<count) {
        unpack_buffer_update = t_buffer_update((T_X_FLOAT*)unpack_buffer.data(),count);
      }
      Kokkos::parallel_for("CommMPI::halo_update_unpack",
                Kokkos::RangePolicy<TagHaloUpdateUnpack, Kokkos::IndexType<T_INT> >(0,proc_num_recv[phase]),
                *this);

    } else {
      //printf("HaloUpdateCopy: %i %i %i\n",phase,proc_num_send[phase],pack_indicies.extent(0));
      Kokkos::parallel_for("CommMPI::halo_update_self",
        Kokkos::RangePolicy<TagHaloUpdateSelf, Kokkos::IndexType<T_INT> >(0,proc_num_send[phase]),
        *this);
    }
    N_ghost += proc_num_recv[phase];
  }

  Kokkos::Profiling::popRegion();
};
```

pushRegion("Comm::update_halo")

Kokkos::parallel_for

popRegion

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ExaMiniMD: TAU Phase

TAU: ParaProf: Statistics for: node 0, thread 0 - examinimd_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	0	0.504	190	190
OpenMP_Parallel_Region parallel_for<Kokkos::RangePolicy<CommMPI::Ta	0.08	0.968	190	190
OpenMP_Parallel_Region void Kokkos::parallel_for<Kokkos::RangePolicy<(	0.001	0.594	380	380
OpenMP_Sync_Region_Barrier parallel_for<Kokkos::RangePolicy<CommMI	0.489	0.489	190	0
OpenMP_Sync_Region_Barrier parallel_for<Kokkos::RangePolicy<CommMI	0.875	0.875	190	0
OpenMP_Sync_Region_Barrier void Kokkos::parallel_for<Kokkos::RangePol	0.58	0.58	380	0

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

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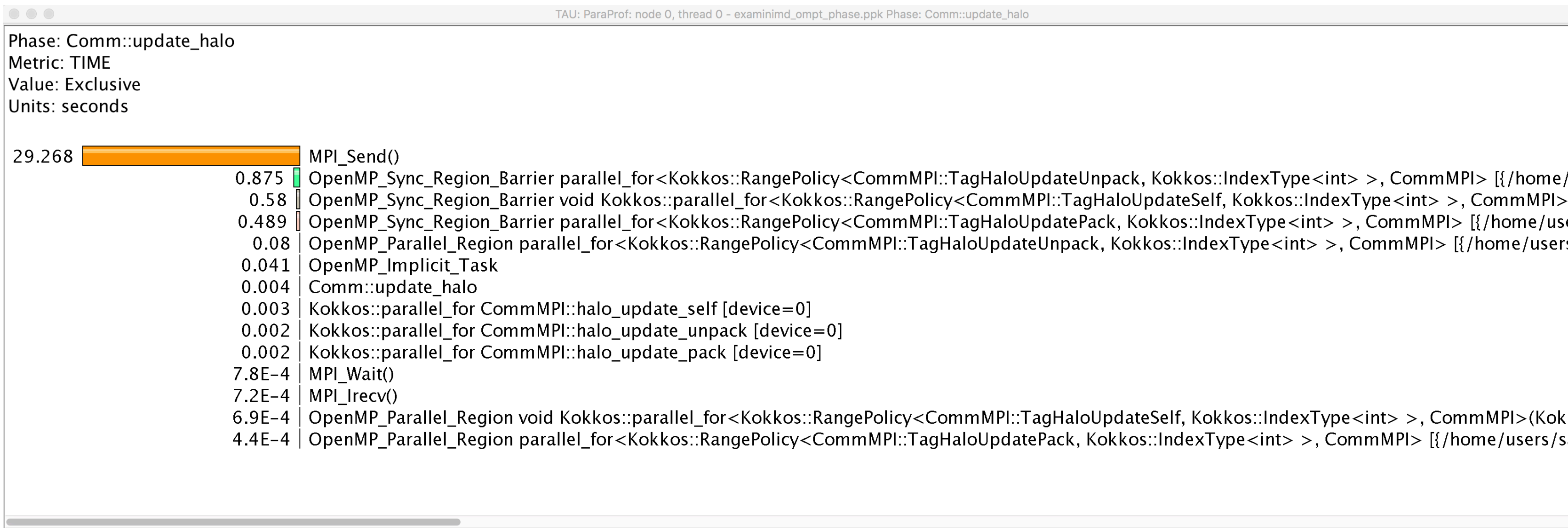
ExaMiniMD: ParaProf Node Window



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Event-based Sampling (EBS): CabanaMD

TAU: ParaProf: Statistics for: node 0, thread 0 - cabana.ppk

Name	Exclusive...	Inclusive...	Calls	Child Calls
.TAU application	0.655	5.132	1	2,424
Comm::update_halo	0.129	1.634	95	21,755
[CONTEXT] Comm::update_halo	0	0.12	3	0
[SAMPLE] __strlen_power8 [{} {0}]	0.09	0.09	2	0
[SAMPLE] Kokkos::Impl::SharedAllocationRecord<void, void>::increment(Kokkos::Impl::SharedAllocationRecord<void, void>*) [{/g/g20/reeve5/bin/CabanaMD}	0.03	0.03	1	0
cudaDeviceSynchronize	0.991	0.991	3,043	0
[CONTEXT] .TAU application	0	0.54	18	0
[SUMMARY] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h}]	0.27	0.27	9	0
[SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {128}]	0.09	0.09	3	0
[SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {129}]	0.09	0.09	3	0
[SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {130}]	0.06	0.06	2	0
[SAMPLE] LAMMPS_RandomVelocityGeom::reset(int, double*) [{/g/g20/reeve5/pr/CabanaMD/src/input.h} {140}]	0.03	0.03	1	0
[SUMMARY] Input::create_lattice(Comm*) [{/g/g20/reeve5/pr/CabanaMD/src/input.cpp}]	0.15	0.15	5	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} {665}]	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] reference<unsigned int, unsigned int, unsigned int> [{/g/g20/reeve5/build_v100/install/kokkos/include/impl/Kokkos_ViewMapping.hpp} {2740}]	0.06	0.06	2	0
[SAMPLE] unsigned long Kokkos::Impl::ViewOffset<Kokkos::Impl::ViewDimension<0ul, 16ul, 3ul>, Kokkos::LayoutCabanaSlice<176, 16, 3, 0, 0, 0, 0, 0>, void>::	0.03	0.03	1	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
MPI_Finalize()	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	0.004	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	0.09	3	0
[SAMPLE] __GI___sched_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}]	0.03	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

Kokkos sample within Comm::update_halo

Kokkos sample within top-level application code

Instrumented Kokkos::parallel_for

Instrumented Kokkos::parallel_reduce

EBS with Kokkos API

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CabanaMD: CUDA Events

TAU: ParaProf: Function Data Window: cabana.ppk

Phase: .TAU application
Name: void
Kokkos::Impl::cuda_parallel_launch_constant_memory<Kokkos::Impl::ParallelFor
<ForceLJ<Cabana::VerletList<Kokkos::Device<Kokkos::Cuda,
Kokkos::CudaUVMSpace>, Cabana::FullNeighborTag, Cabana::VerletLayout2D> >,
Kokkos::RangePolicy<ForceLJ<Cabana::VerletList<Kokkos::Device<Kokkos::Cuda
, Kokkos::CudaUVMSpace>, Cabana::FullNeighborTag, Cabana::VerletLayout2D>
>::TagFullNeigh, Kokkos::IndexType<int> >, Kokkos::Cuda> >()
Metric Name: TAUGPU_TIME
Value: Exclusive
Units: microseconds

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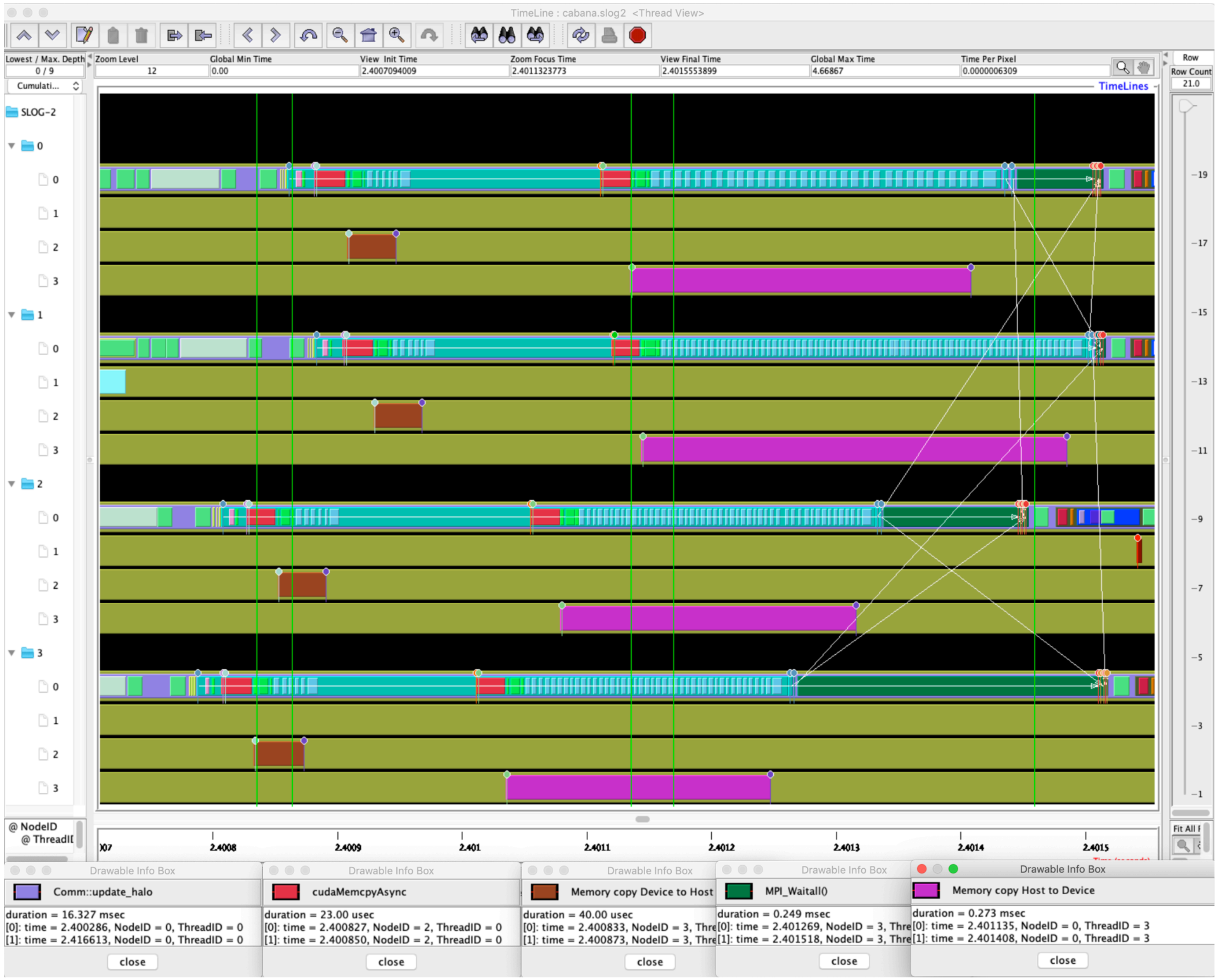
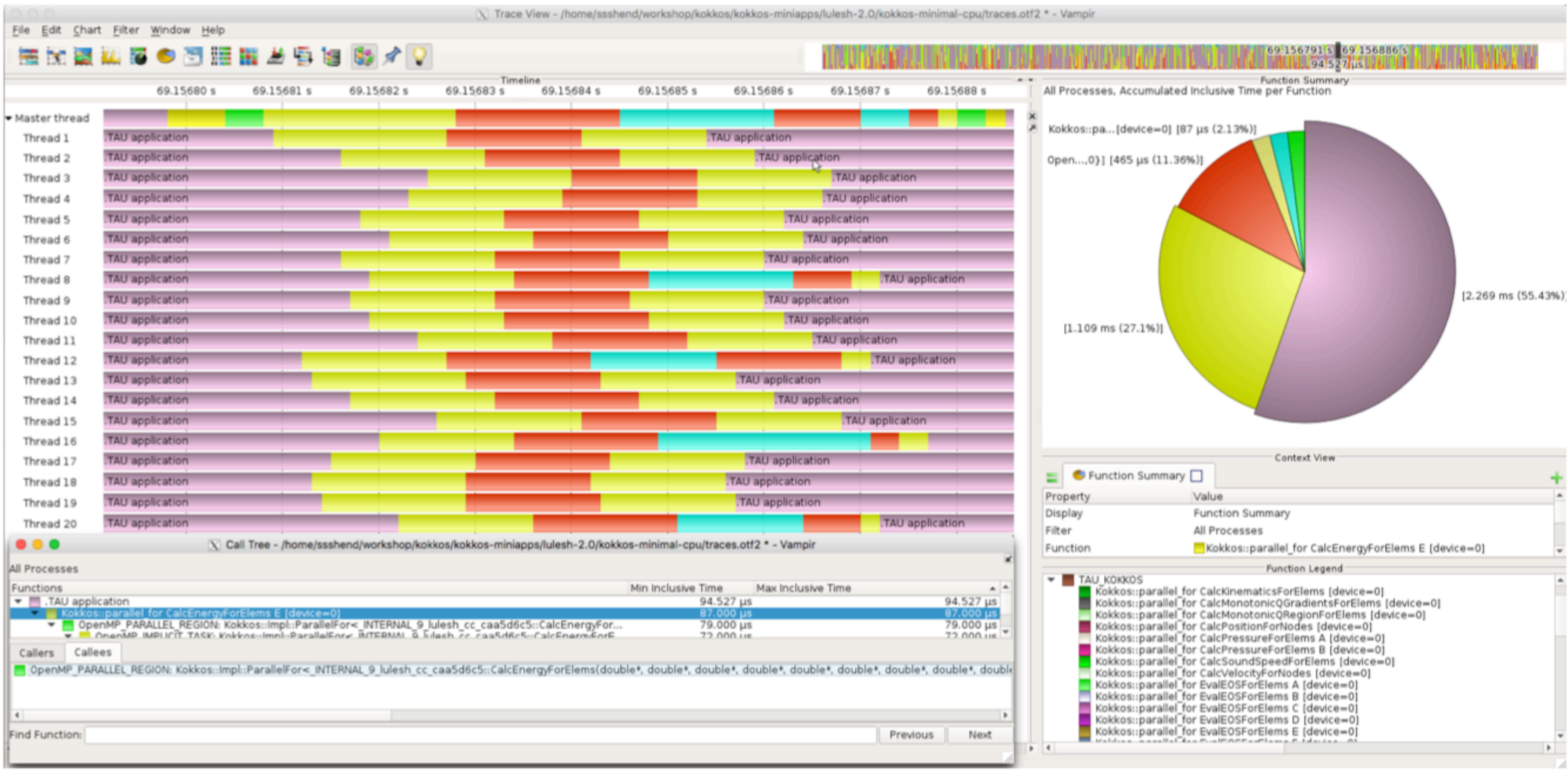
Jumpshot Trace Visualizer



Vampir [TU Dresden] Timeline Display



% export TAU_TRACE=1; export TAU_TRACE_FORMAT=otf2
% mpirun −np 16 tau_exec ./a.out
% vampir traces.otf2

An API model for other runtimes?

- **Kokkos profiling interface is very elegant**
- **Kokkos API calls are defined by the tools**
- **Kokkos maintains compatibility between its releases**
- **No need for a header file, no #defines, type names**
- **Additional calls may be added to the API, but are not necessary for an older version of the tool to support a new version of Kokkos**
- **No need for tool to be compiled with a given version of Kokkos**
- **At startup, if KOKKOS_PROFILE_LBIRARY environment variable is defined, it loads the library, if not, profiling calls are disabled**
- **Profiling hooks are activated by loading the agent library**
- **Hooks may be disabled during configuration, enabled by default**
- **Is this a good model for other runtimes to adopt?**
- **Is there a need for a single tool to provide access to events across different runtimes/programming models?**

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http://exascaleproject.org

Download TAU

http://tau.uoregon.edu

http://taucommander.com

https://e4s.io

[E4S: Extreme-Scale Scientific Software Stack]

For more info on E4S: E4S BoF, Tues, 12:15pm, Room #405-407

Free download, open source, BSD license

Reference

Installing and Configuring TAU

•Installing PDT:

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

•Installing TAU:

- wget tau.uoregon.edu/tau.tgz;   tar zxf tau.tgz; cd tau-2.<ver>
- wget http://tau.uoregon.edu/ext.tgz ; tar xf ext.tgz
- ./configure -bfd=download -pdt=<dir>
  -iowrapper -mpi −dwarf=download −unwind=download −otf=download −papi=<dir>
  make install

•Using TAU:

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

Compile-Time Options

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

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

Compile-Time Options (contd.)

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

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

See tau_compiler.sh for a full list of TAU_OPTIONS.

…

TAU's Runtime Environment Variables

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

Runtime Environment Variables

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