GPU Profiling:

Performance Timelines with Rocprof and Omnitrace

Suyash Tandon
HIP Lecture Series – 04
October 2nd, 2023

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AMD Profilers

ROC-profiler (rocprof)

Hardware Counters	Raw collection of GPU counters and traces Counter collection with user input files Counter results printed to a CSV
Traces and timelines	Trace collection support for CPU copy · HIP API · HSA API · GPU Kernels
Visualisation	Traces visualized with Perfetto

	A	B	C	D	E
1	Name	Calls	TotalDura	AverageNs	Percentage
2	hipMemcpyAsync	99	3.22E+10	3.25E+08	44.14872
3	hipEventSynchronize	330	2.42E+10	73394557	33.225
4	hipMemsetAsync	87	7.76E+09	89232696	10.64953
5	hipHostMalloc	9	5.41E+09	6.01E+08	7.415198
6	hipDeviceSynchronize	28	1.32E+09	47006288	1.805515
7	hipHostFree	17	1.05E+09	61534688	1.435014
8	hipMemcpy	41	8.11E+08	19791876	1.113161
9	hipLaunchKernel	1856	58082083	31294	0.079676
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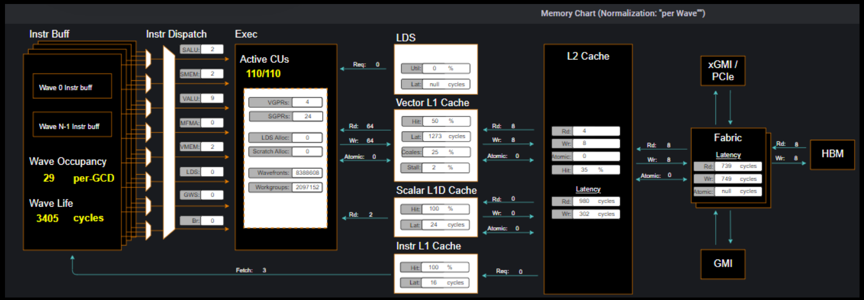
22	hipGetDevice	64	11611	181	1.59E-05
23	hipSetDevice	1	401	401	5.50E-07
24	hipGetDeviceCount	1	220	220	3.02E-07

Omnitrace

Trace collection	Comprehensive trace collection CPU · GPU
Supports	CPU copy · HIP API · HSA API · GPU Kernels OpenMP® · MPI · Kokkos · p-threads · multi-GPU
Visualisation	Traces visualized with Perfetto

Omniperf

Performance Analysis	Automated collection of hardware counters Analysis · Visualisation
Supports	Speed of Light · Memory chart · Rooflines · Kernel comparison
Visualisation	With Grafana or standalone GUI



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Agenda – AMD Profilers with timeline profiling support

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- Counter results printed to a CSV

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- CPU copy | HIP API | HSA API | GPU Kernels

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- CPU | GPU

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- OpenMP® | MPI | Kokkos | p-threads | multi-GPU

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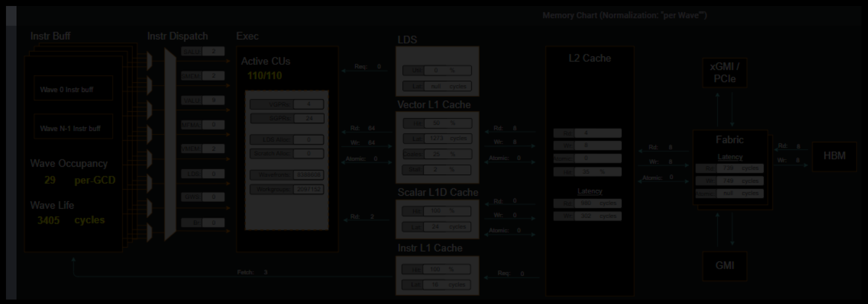
Omniperf

Performance Analysis
- Automated collection of hardware counters
- Analysis | Visualisation

Supports
- Speed of Light | Memory chart | Rooflines | Kernel comparison

Visualisation
- With Grafana or standalone GUI

**Will be covered in HIP Training Series 05*



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Background – AMD Profilers

Objective	Where should I focus my time ?	How well am I using the GPU ?	Why am I seeing this performance ?
Approach	Timelines/Traces/Profiles/Causal-Profiles	Roofline	Hardware counters
AMD Tools	rocprof		

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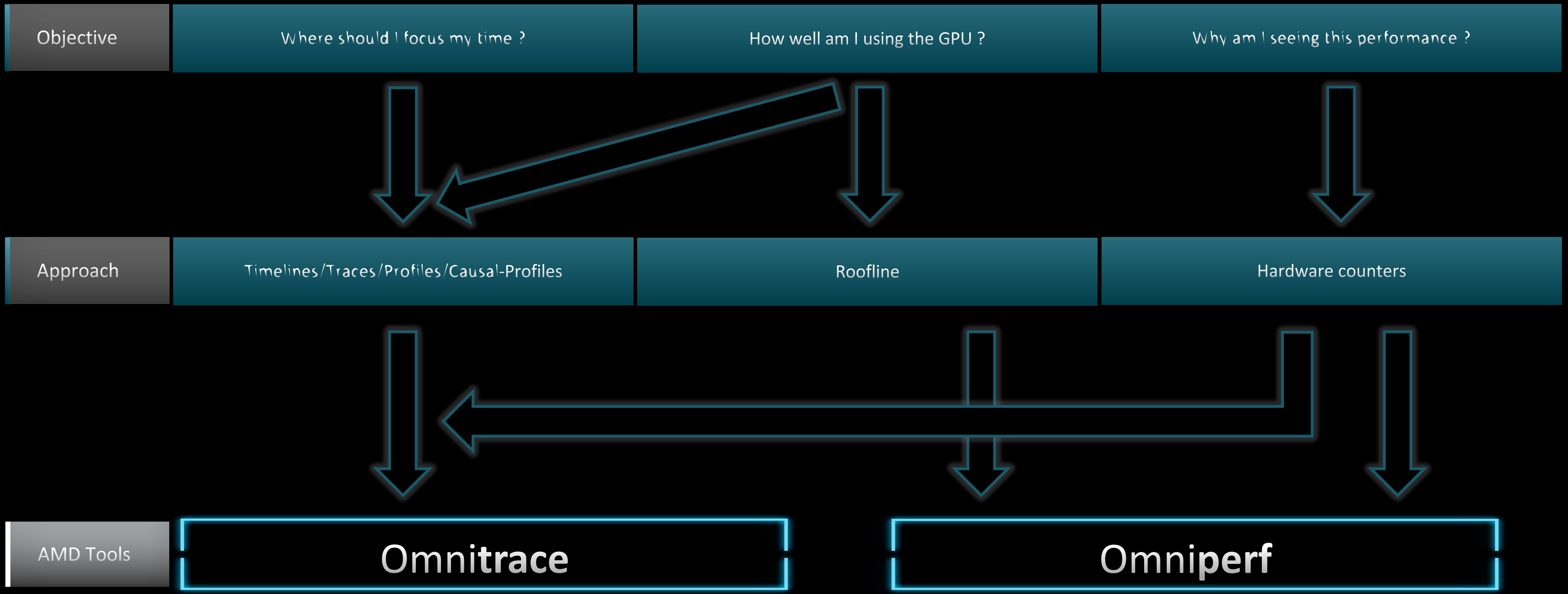
Background – AMD Profilers



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Why use a timeline profile

GPU centric

- Visualize the application performance
- Understand the interactions between a program’s operations
- Reveal hidden data transfer and other implicit operations
- Understand multiple stream dependencies and performance

CPU and GPU timelines

- Understand interaction between CPU and GPU
- Understand MPI communication process
- Track memory usage
- See hardware temperatures and frequencies

What is ROC-Profiler?

- ROC-profiler (also referred to as `rocprof`) is the command line front-end for AMD's GPU profiling libraries
  - Repo: https://github.com/ROCm-Developer-Tools/rocprofiler

- rocprof contains the central components allowing application traces and counter collection
  - Under constant development

- Distributed with ROCm

- The output of `rocprof` can be visualized in the Chrome browser with Perfetto (https://ui.perfetto.dev/)

rocprof: Getting Started + Useful Flags

- To get help:
  `${ROCM_PATH}/bin/rocprof -h`
- Useful housekeeping flags:
  - `--timestamp <on|off>` - turn on/off gpu kernel timestamps
  - `--basenames <on|off>` - turn on/off truncating gpu kernel names (i.e., removing template parameters and argument types)
  - `-o <output csv file>` - Direct counter information to a particular file name
  - `-d <data directory>` - Send profiling data to a particular directory
  - `-t <temporary directory>` - Change the directory where data files typically created in /tmp are placed. This allows you to save these temporary files.
- Flags directing rocprofiler activity:
  - `-i input<.txt|.xml>` - specify an input file (note the output files will now be named input.*)
  - `--hsa-trace` - to trace GPU Kernels, host HSA events (more later) and HIP memory copies.
  - `--hip-trace` - to trace HIP API calls
  - `--roctx-trace` - to trace roctx markers
  - `--kfd-trace` - to trace GPU driver calls
- Advanced usage
  - `-m <metric file>` - Allows the user to define and collect custom metrics. See rocprofiler/test/tool/*.xml on GitHub for examples.

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rocprof: Kernel Information

- rocprof can collect kernel(s) execution stats

  `$ /opt/rocm/bin/rocprof --stats --basenames on <app with arguments>`

- This will output two csv files:
  - `results.csv`: information per each call of the kernel
  - `results.stats.csv`: statistics grouped by each kernel
- Content of `results.stats.csv` provides the list of GPU kernels with their durations and percentage of total GPU time:

```
"Name","Calls","TotalDurationNs","AverageNs","Percentage"
"JacobiIterationKernel",1000,556699359,556699,43.291753895270446
"NormKernel1",1001,430797387,430367,33.500980655394606
"LocalLaplacianKernel",1000,280014065,280014,21.775307970480817
"HaloLaplacianKernel",1000,14635177,14635,1.1381052818810995
"NormKernel2",1001,3770718,3766,0.2932300765671734
"__amd_rocclr_fillBufferAligned.kd",1,8000,8000,0.0006221204058583505
```

- In a spreadsheet viewer, it is easier to read:

	A	B	C	D	E
1	Name	Calls	TotalDurationNs	AverageNs	Percentage
2	JacobiIterationKernel	1000	556699359	556699	43.2917538952704
3	NormKernel1	1001	430797387	430367	33.5009806553946
4	LocalLaplacianKernel	1000	280014065	280014	21.7753079704808
5	HaloLaplacianKernel	1000	14635177	14635	1.1381052818811
6	NormKernel2	1001	3770718	3766	0.293230076567173
7	__amd_rocclr_fillBufferAligned	1	8000	8000	0.000622120405858

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rocprof: Collecting Application Traces

- rocprof can collect a variety of trace event types, and generate timelines in JSON format for use with Perfetto, currently:

Trace Event	rocprof Trace Mode
HIP API call	`--hip-trace`
GPU Kernels	`--hip-trace`
Host <-> Device Memory copies	`--hip-trace`
CPU HSA Calls	`--hsa-trace`
User code markers	`--roctx-trace`

- You can combine modes like `--hip-trace --hsa-trace`
- If profiling OpenMP offload code, `--hsa-trace` is required to show HSA activity

rocprof + Perfetto: Collecting and Visualizing Application Traces

- rocprof can collect traces

```
$ /opt/rocm/bin/rocprof --hip-trace <app with arguments>
```

This will output a `.json` file that can be visualized using the chrome browser and Perfetto (https://ui.perfetto.dev/)

Perfetto – timeline visualization tool

- Both rocprof and Omnitrace currently use Perfetto for timeline presentation
- Perfetto is a built-in timeline visualization tool in the Chrome browser
- Original purpose was to profile android applications
- Open-source application from Google®
- Accessed through https://ui.perfetto.dev/ to invoke tool

  ```
  Does not go over internet
  Works even if off-line
  No server interaction
  ```

- Opens file and reads local profile data in several formats

rocprof + Perfetto: Collecting and Visualizing Application Traces

- rocprof can collect traces

```
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```
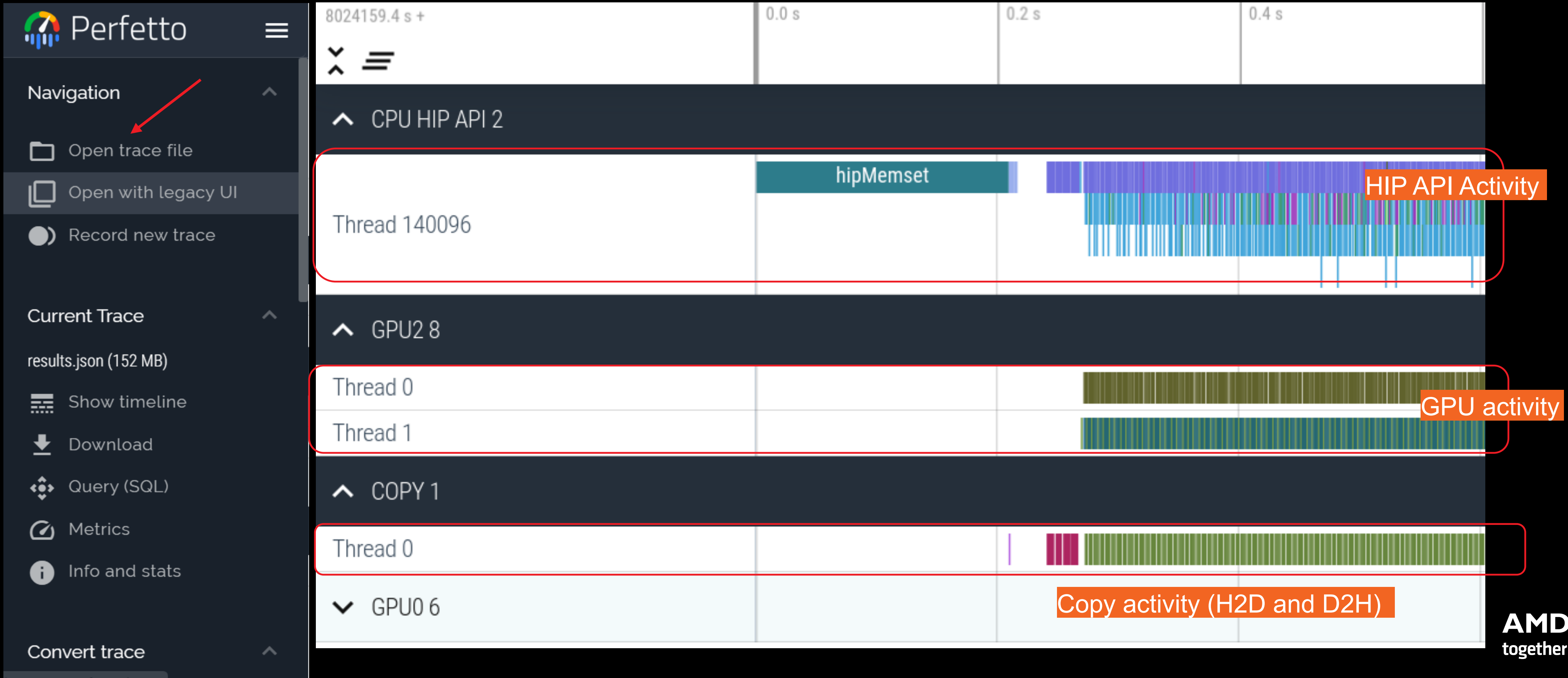
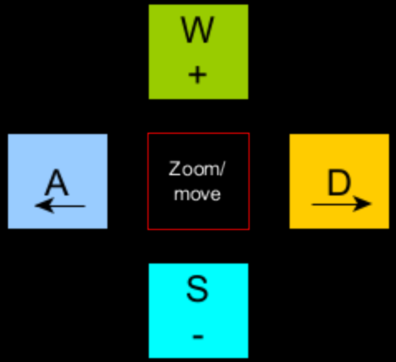
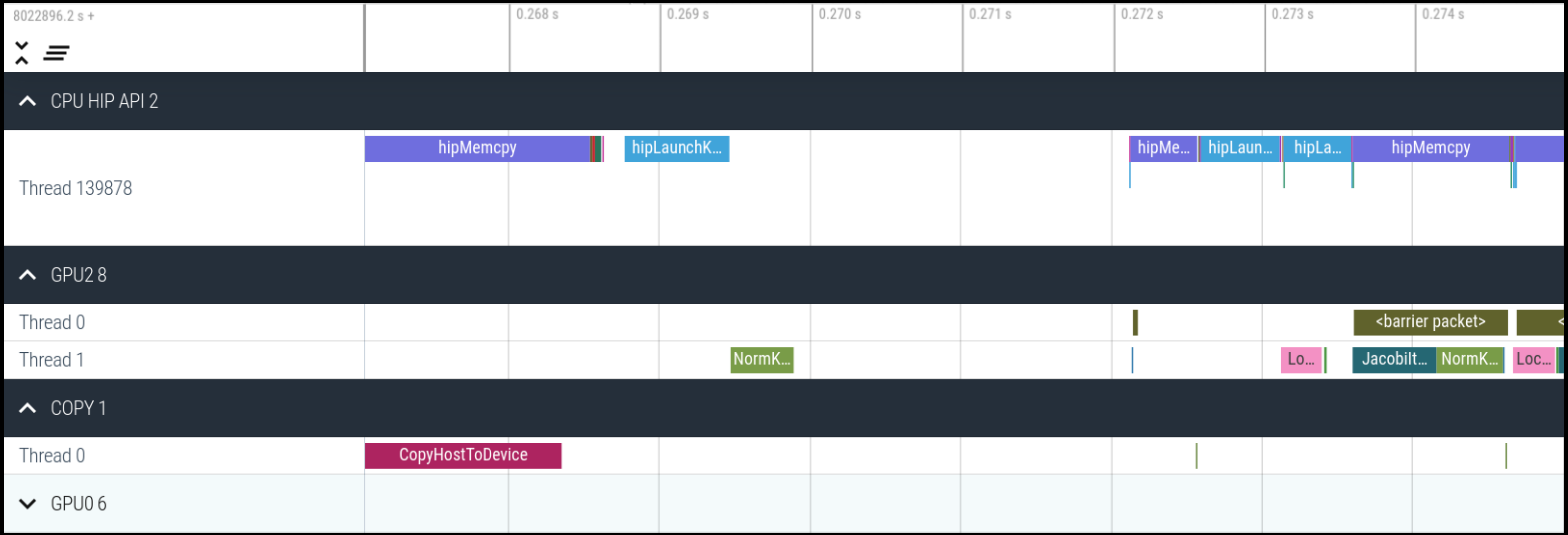

This will output a `.json` file that can be visualized using the chrome browser and Perfetto (https://ui.perfetto.dev/)



Perfetto: Visualizing Application Traces

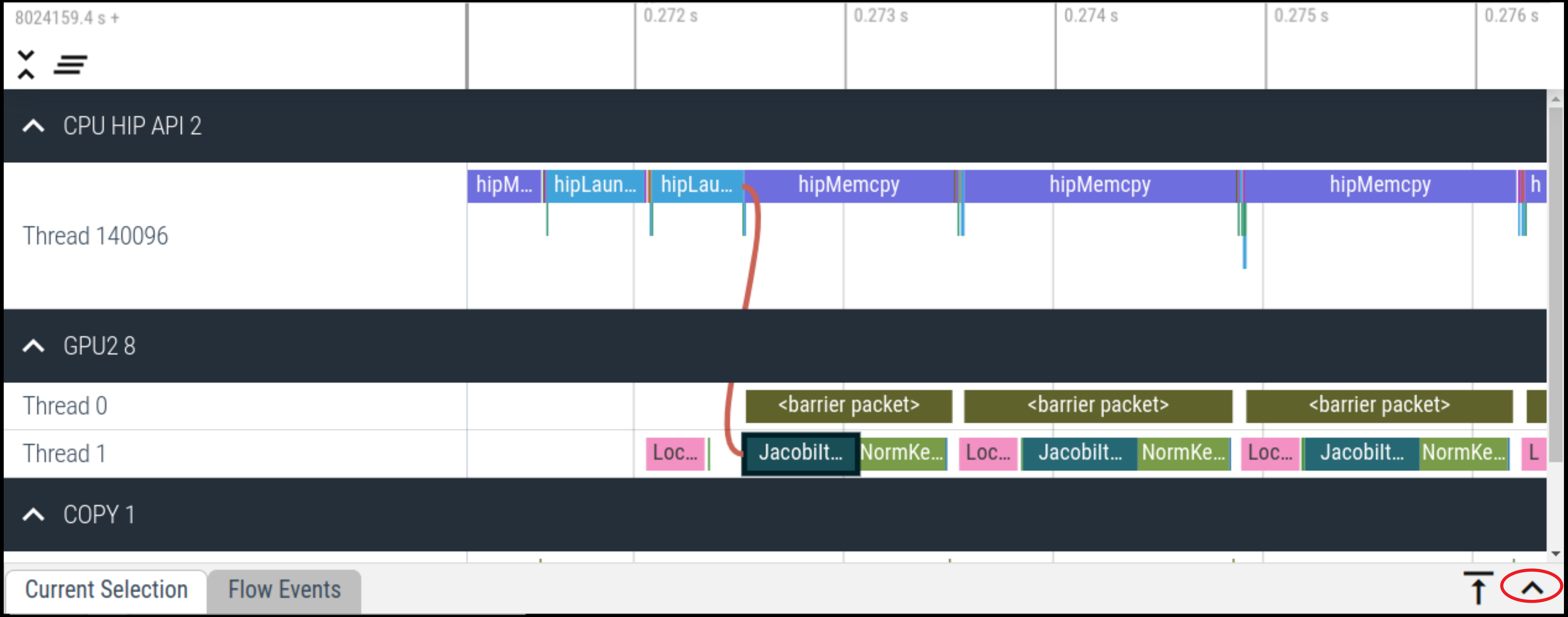
- Zoom in to see individual events
- Navigate trace using WASD keys





Perfetto: Kernel Information and Flow Events

- Zoom and select a kernel, you can see the link to the HIP call launching the kernel
- Try to open the information for the kernel (button at bottom right)



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Perfetto: Kernel Information and Flow Events

Current Selection | Flow Events

Slice Details

Name	JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)
Category	null
Start time	272ms 523us 999ns
Duration	541us
Thread duration	0s (0.00%)
Thread	1
Process	GPU2 8
Slice ID	57

Duration

Preceding flows

Slice	↗ hipLaunchKernel
Delay	6us
Thread	NULL (CPU HIP API 2)

Arguments

args

BeginNs	8024159641088210
Data	NULL
DurationNs	541599
EndNs	8024159641629809
Name	JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)
pid	140096
tid	140096
dev-id	2
queue-id	1
stream-id	1

Kernel name and args

Stream where kernel was launched in

Current Selection | Flow Events

Flow events

Direction	Duration	Connected Slice ID	Connected Slice Name	Thread Out	Thread In	Process Out	Process In	Flow Category	Flow Name
Incoming	6us	52	hipLaunchKernel	NULL	NULL	CPU HIP API 2	GPU2 8	DataFlow	dep

rocprof: Collecting Application Traces with rocTX Markers and Regions

- rocprof can collect user defined regions or markers using rocTX
- Annotate code with roctx regions:

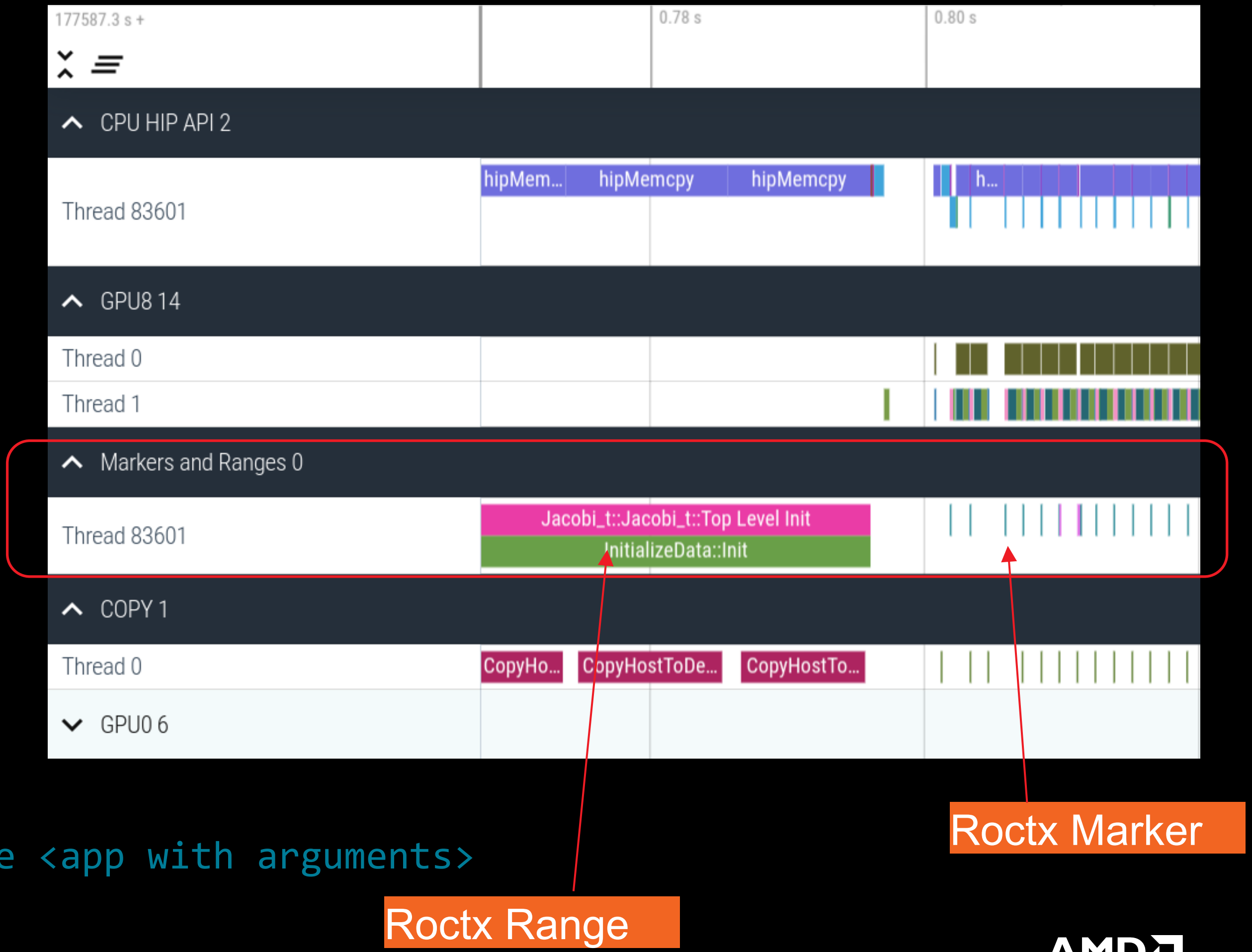
```
#include <roctx.h>
...
    roctxRangePush("reduce_for_c");
    reduce_function ();
    roctxRangePop();
...
```

- Annotate code with roctx markers:

```
...
    roctxMark("start of some code");
    // some_code
    roctxMark("end of some code");
...
```

- Add roctx and roctracer libraries to link line:
  `-L${ROCM_PATH}/lib -lroctx64 -lroctracer64`

- Profile with `--roctx-range` option:
  `$ /opt/rocm/bin/rocprof --hip-trace --roctx-trace <app with arguments>`



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rocprof: Collecting Hardware Counters

- rocprof can collect a number of hardware counters and derived counters
  - `$ /opt/rocm/bin/rocprof --list-basic`
  - `$ /opt/rocm/bin/rocprof --list-derived`

- Specify counters in a counter file. For example:
  - `$ /opt/rocm/bin/rocprof -i rocprof_counters.txt <app with args>`
  - `$ cat rocprof_counters.txt`

```
pmc : Wavefronts VALUInsts VFetchInsts VWriteInsts VALUUtilization VALUBusy WriteSize
pmc : SALUInsts SFetchInsts LDSInsts FlatLDSInsts GDSInsts SALUBusy FetchSize
pmc : L2CacheHit MemUnitBusy MemUnitStalled WriteUnitStalled ALUStalledByLDS LDSBankConflict
```

  - A limited number of counters can be collected during a specific pass of code
    - Each line in the counter file will be collected in one pass
    - You will receive an error suggesting alternative counter ordering if you have too many / conflicting counters on one line

  - A csv file will be created containing all the requested counters for each invocation of every kernel

rocprof: Commonly Used GPU Counters

VALUUtilization	The percentage of ALUs active in a wave. Low VALUUtilization is likely due to high divergence or a poorly sized grid
VALUBusy	The percentage of GPUTime vector ALU instructions are processed. Can be thought of as something like compute utilization
FetchSize	The total kilobytes fetched from global memory
WriteSize	The total kilobytes written to global memory
L2CacheHit	The percentage of fetch, write, atomic, and other instructions that hit the data in L2 cache
MemUnitBusy	The percentage of GPUTime the memory unit is active. The result includes the stall time
MemUnitStalled	The percentage of GPUTime the memory unit is stalled
WriteUnitStalled	The percentage of GPUTime the write unit is stalled

Full list at: https://github.com/ROCm-Developer-Tools/rocprofiler/blob/amd-master/test/tool/metrics.xml

Performance Counters Tips and Tricks

- GPU Hardware counters are global
  - Kernel dispatches are serialized to ensure that only one dispatch is ever in flight
  - It is recommended that no other applications are using the GPU when collecting performance counters

- Use `--basenames on` which will report only kernel names, leaving off kernel arguments

- How do you time a kernel's duration?
  - `$ /opt/rocm/bin/rocprof --timestamp on -i rocprof_counters.txt <app with args>`
  - This produces four times: `DispatchNs`, `BeginNs`, `EndNs`, and `CompleteNs`
  - Closest thing to a kernel duration: `EndNs - BeginNs`
  - If you run with "`--stats`" the resultant results.stats.csv file will include a kernel duration column
    - Note: the duration is aggregated over repeated calls to the same kernel

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rocprof: Multiple MPI Ranks

- rocprof can collect counters and traces for multiple MPI ranks
- Say you want to profile an application usually called like this:

```
mpiexec –np <n> ./Jacobi_hip –g <x> <y>
```

- Invoke the profiler by executing:

```
mpiexec -np <n> rocprof <rocprof_options> ./Jacobi_hip -g <x> <y>
or
srun --ntasks=n rocprof <rocprof_options> ./Jacobi_hip -g <x> <y>
```

- By directing output files from each rank to different directories, we can collect traces for each rank separately
  - Use a helper script for this, and run your program as shown below:

```
mpiexec -np <n> helper_rocprof.sh ./Jacobi_hip -g <x> <y>
```

- Multi-node profiling currently isn’t supported

Profiling Multiple MPI Ranks

```
$cat helper_rocprof.sh

    #!/bin/bash
    set -euo pipefail
    # depends on ROCM_PATH being set outside;  input arguments are the output directory & the name
    outdir="$1"
    name="$2"
    if [[ -n ${OMPI_COMM_WORLD_RANK+z} ]]; then
        # mpich
        export MPI_RANK=${OMPI_COMM_WORLD_RANK}
    elif [[ -n ${MV2_COMM_WORLD_RANK+z} ]]; then
        # ompi
        export MPI_RANK=${MV2_COMM_WORLD_RANK}
    elif [[ -n ${SLURM_PROCID+z} ]]; then
        export MPI_RANK=${SLURM_PROCID}
    else
        echo "Unknown MPI layer detected! Must use OpenMPI, MVAPICH, or SLURM"
        exit 1
    fi
    rocprof="${ROCM_PATH}/bin/rocprof"

    pid="$$"
    outdir="${outdir}/rank_${pid}_${MPI_RANK}"
    outfile="${name}_${pid}_${MPI_RANK}.csv"
    ${rocprof} -d ${outdir} --hsa-trace -o ${outdir}/${outfile} "${@:3}"
```

Output directory per rank

Filenames annotated with rank as well

Application and its arguments

Trace mode

rocprof: Profiling Overhead

- As with every profiling tool, there is an overhead
- The percentage of the overhead depends on the profiling options used
  - For example, tracing is faster than hardware counter collection
- When collecting many counters, the collection may require multiple passes
- With rocTX markers/regions, tracing can take longer and the output may be large
  - Sometimes too large to visualize
- The more data collected, the more the overhead of profiling
  - Depends on the application and options used

Summary

- rocprof is the open source, command line AMD GPU profiling tool distributed with ROCm
- Many other tools are built over rocprof
- rocprof provides tracing of GPU kernels, HIP API, HSA API and Copy activity
- rocprof can be used to collect GPU hardware counters with additional overhead
- JSON Traces can be viewed in Perfetto UI
- Other output files are in text/CSV format

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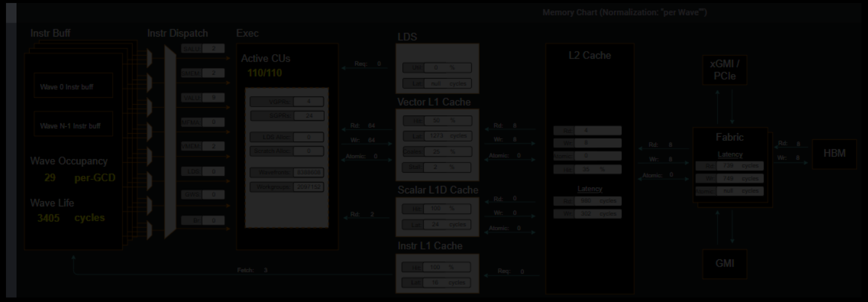

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Omnitrace: Application Profiling, Tracing, and Analysis

AMD Research Tool
- Repository: https://github.com/AMDResearch/omnitrace
- Not part of ROCm stack

Language Support
- C/C++
- Fortran
- Python
- OpenCL ™

Data Collection Modes
- Dynamic instrumentation
- Statistical/process sampling
- Causal Profiling

Data Analysis
- High-level summary
- Comprehensive trace
- Critical trace analysis

Parallelism Support
- MPI
- OpenMP®
- Pthreads
- HIP
- HSA
- Kokkos

GPU Metrics
- HW counters
- HSA API
- HIP API
- HIP trace
- HSA trace
- Memory & thermal

CPU Metrics
- HW counters
- Timing metrics
- Memory access
- Network
- I/O
- more…

Refer to current documentation for recent updates

Installation (if required)

To use pre-built binaries, select the version that matches your operating system, ROCm version, etc.

Select OpenSuse/RHEL operating system for HPE/AMD system:

omnitrace-1.10.1-rhel-9.0-ROCm-50500-PAPI-OMPT-Python3.sh

There are .rpm and .deb fpackages along with .sh scripts for installation.

Full documentation: https://amdresearch.github.io/omnitrace/

```
export OMNITRACE_VERSION=latest
export ROCM_VERSION=5.6.0
export OMNITRACE_INSTALL_DIR=</path/to/your/omnitrace/install>
wget https://github.com/AMDResearch/omnitrace/releases/${OMNITRACE_VERSION}/download/omnitrace-install.py
python3 omnitrace-install.py -p ${OMNITRACE_INSTALL_DIR} --rocm ${ROCM_VERSION}

Set up environment:
source ${OMNITRACE_INSTALL_DIR}/share/omnitrace/setup-env.sh
```

Note: If installing from source, remember to clone the omnitrace repo recursively

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Omnitrace instrumentation Modes

Runtime Instrumentation	Dynamic binary instrumentation		
	Characterize performance	Sample every invocation	Large overheads
Sampling Instrumentation	Periodic sampling of entire application		
	Statistical sampling	Process sampling	

Basic command-line syntax:

```
$ omnitrace [omnitrace-options] -- <CMD> <ARGS>
```

For more information or help use -h/--help/? flags:

```
$ omnitrace -h
```

Can also execute on systems using a job scheduler. For example, with SLURM, an interactive session can be used as:

```
$ srun [options] omnitrace [omnitrace-options] -- <CMD> <ARGS>
```

For problems, create an issue here: https://github.com/AMDResearch/omnitrace/issues
Documentation: https://amdresearch.github.io/omnitrace/

Omnitrace Configuration

```
$ omnitrace-avail --categories [options]
```

Get more information about run-time settings, data collection capabilities, and available hardware counters. For more information or help use -h/--help flags:

```
$ omnitrace-avail -h
```

Collect information for omnitrace-related settings using shorthand -c for --categories :

```
$ omnitrace-avail –c perfetto
```

```
$ omnitrace-avail -c perfetto
|-------------------------------------|-----------------|-------------------------------------------------------------------------|
|        ENVIRONMENT VARIABLE         |      VALUE      |                               CATEGORIES                                |
|-------------------------------------|-----------------|-------------------------------------------------------------------------|
| OMNITRACE_PERFETTO_BACKEND          |    inprocess    | custom, libomnitrace, omnitrace, perfetto                               |
| OMNITRACE_PERFETTO_BUFFER_SIZE_KB   |     1024000     | custom, data, libomnitrace, omnitrace, perfetto                         |
| OMNITRACE_PERFETTO_FILL_POLICY      |     discard     | custom, data, libomnitrace, omnitrace, perfetto                         |
| OMNITRACE_TRACE_DELAY               |        0        | custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace     |
| OMNITRACE_TRACE_DURATION            |        0        | custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace     |
| OMNITRACE_TRACE_PERIODS             |                 | custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace     |
| OMNITRACE_TRACE_PERIOD_CLOCK_ID     | CLOCK_REALTIME  | custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace     |
| OMNITRACE_USE_PERFETTO              |      true       | backend, custom, libomnitrace, omnitrace, perfetto                      |
|-------------------------------------|-----------------|-------------------------------------------------------------------------|
```

Shows all runtime settings that may be tuned for perfetto

Omnitrace Configuration

```
$ omnitrace-avail --categories [options]
```

Get more information about run-time settings, data collection capabilities, and available hardware counters. For more information or help use -h/--help/? flags:

```
$ omnitrace-avail -h
```

Collect information for omnitrace-related settings using shorthand -c for --categories :

```
$ omnitrace-avail –c omnitrace
```

For brief description, use the options:

```
$ omnitrace-avail –bd
```

ENVIRONMENT VARIABLE	DESCRIPTION
OMNITRACE_CAUSAL_BINARY_EXCLUDE	Excludes binaries matching the list of provided regexes from causal experiments (separated by tab, sem...
OMNITRACE_CAUSAL_BINARY_SCOPE	Limits causal experiments to the binaries matching the provided list of regular expressions (separated...
OMNITRACE_CAUSAL_DELAY	Length of time to wait (in seconds) before starting the first causal experiment
OMNITRACE_CAUSAL_DURATION	Length of time to perform causal experimentation (in seconds) after the first experiment has started. ...
OMNITRACE_CAUSAL_FUNCTION_EXCLUDE	Excludes functions matching the list of provided regexes from causal experiments (separated by tab, se...
OMNITRACE_CAUSAL_FUNCTION_SCOPE	List of <function> regex entries for causal profiling (separated by tab, semi-colon, and/or quotes (si...
OMNITRACE_CAUSAL_RANDOM_SEED	Seed for random number generator which selects speedups and experiments -- please note that the lines ...
OMNITRACE_CAUSAL_SOURCE_EXCLUDE	Excludes source files or source file + lineno pair (i.e. <file> or <file>:<line>) matching the list of...
OMNITRACE_CAUSAL_SOURCE_SCOPE	Limits causal experiments to the source files or source file + lineno pair (i.e. <file> or <file>:<lin...
OMNITRACE_CONFIG_FILE	Configuration file for omnitrace
OMNITRACE_CRITICAL_TRACE	Enable generation of the critical trace
OMNITRACE_ENABLED	Activation state of timemory
OMNITRACE_OUTPUT_PATH	Explicitly specify the output folder for results
OMNITRACE_OUTPUT_PREFIX	Explicitly specify a prefix for all output files
OMNITRACE_PAPI_EVENTS	PAPI presets and events to collect (see also: papi_avail)
OMNITRACE_PERFETTO_BACKEND	Specify the perfetto backend to activate. Options are: 'inprocess', 'system', or 'all'
OMNITRACE_PERFETTO_BUFFER_SIZE_KB	Size of perfetto buffer (in KB)
OMNITRACE_PERFETTO_FILL_POLICY	Behavior when perfetto buffer is full. 'discard' will ignore new entries, 'ring_buffer' will overwrite...
OMNITRACE_PROCESS_SAMPLING_DURATION	If > 0.0, time (in seconds) to sample before stopping. If less than zero, uses OMNITRACE_SAMPLING_DURA...
OMNITRACE_PROCESS_SAMPLING_FREQ	Number of measurements per second when OMNITTRACE_USE_PROCESS_SAMPLING=ON. If set to zero, uses OMNITR...
OMNITRACE_ROCM_EVENTS	ROCm hardware counters. Use ':device=N' syntax to specify collection on device number N, e.g. ':device...
OMNITRACE_SAMPLING_CPUS	CPUs to collect frequency information for. Values should be separated by commas and can be explicit or...
OMNITRACE_SAMPLING_DELAY	Time (in seconds) to wait before the first sampling signal is delivered, increasing this value can fix...
OMNITRACE_SAMPLING_DURATION	If > 0.0, time (in seconds) to sample before stopping
OMNITRACE_SAMPLING_FREQ	Number of software interrupts per second when OMNITRACE_USE_SAMPLING=ON
OMNITRACE_SAMPLING_GPUS	Devices to query when OMNITRACE_USE_ROCM_SMI=ON. Values should be separated by commas and can be expli...

Create a config file

Create a config file in $HOME:

```
$ omnitrace-avail –G $HOME/.omnitrace.cfg
```

To add description of all variables and settings, use:

```
$ omnitrace-avail –G $HOME/.omnitrace.cfg --all
```

Modify the config file $HOME/.omnitrace.cfg as desired to enable and change settings:

```
<snip>
OMNITRACE_USE_PERFETTO          = true
OMNITRACE_USE_TIMEMORY          = true
OMNITRACE_USE_SAMPLING          = false
OMNITRACE_USE_ROCTRACER         = true
OMNITRACE_USE_ROCM_SMI          = true
OMNITRACE_USE_KOKKOSP           = false
OMNITRACE_USE_CAUSAL            = false
OMNITRACE_USE_MPIP              = true
OMNITRACE_USE_PID               = true
OMNITRACE_USE_ROCPROFILER       = true
OMNITRACE_USE_ROCTX
<snip>
```

Contents of the config file

Declare which config file to use by setting the environment:

```
$ export OMNITRACE_CONFIG_FILE=/path-to/.omnitrace.cfg
```


AMD
together we advance_

Dynamic Instrumentation

Runtime Instrumentation

Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
 $ time .mpirun -np 1 ./Jacobi_hip -g 1 1
real     0m2.115s
```

Dynamic instrumentation

```
 $ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1

 real 1m45.742s
```

Extra time is the overhead of dyninst reading every binary that is loaded, not overhead of omnitrace during app execution

Parsing libraries

Functions instrumented

Outputs that will be created

```
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.322 sec and 70.724 MB
[omnitrace][exe] Processing 72 modules...
[omnitrace][exe] Processing 72 modules... Done (0.101 sec, 12.084 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip'. Enabling MPI support
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe]    2 instrumented funcs in ../../orte/orted/orted_submit.c
[omnitrace][exe]    1 instrumented funcs in libamd_comgr.so.2.4.50403
[omnitrace][exe]   15 instrumented funcs in libamdhip64.so.5.4.50403
[omnitrace][exe]    1 instrumented funcs in libm-2.28.so
[omnitrace][exe]   10 instrumented funcs in libmpi.so.40.20.3
[omnitrace][exe]    8 instrumented funcs in libopen-pal.so.40.20.3
[omnitrace][exe]   17 instrumented funcs in libopen-rte.so.40.20.3
[omnitrace][exe]    2 instrumented funcs in libtinfo.so.5.9
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/overlapping.txt'... Done
[omnitrace][exe] Executing...
[omnitrace][1649192][omnitrace_init_tooling] Instrumentation mode: Trace

   omnitrace v1.8.0
```

Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
 $ time .mpirun -np 1 ./Jacobi_hip -g 1 1
real    0m2.115s
```

Dynamic instrumentation

```
 $ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1

 real 1m45.742s
```

Available functions to instrument:

```
 $ mpirun -np 1 omnitrace-instrument -v 1 --simulate --
print-available functions -- ./Jacobi_hip -g 1 1
```

Here, -v gives a verbose output from omnitrace

The simulate flag does not run the executable, but only demonstrates the available functions

```
[available] HaloExchange.cpp:
[available]     [HaloExchange.cold.21][14]
[available]     [HaloExchange][1267]
[available]     [_GLOBAL__sub_I_HaloExchange.cpp][8]

[available] Input.cpp:
[available]     [ExtractNumber][19]
[available]     [FindAndClearArgument][38]
[available]     [ParseCommandLineArguments][206]
[available]     [PrintUsage][12]

[available] JacobiIteration.cpp:
[available]     [JacobiIteration][71]

[available] JacobiMain.cpp:
[available]     [main.cold.0][5]
[available]     [main][35]

[available] JacobiRun.cpp:
[available]     [Jacobi_t::Run][155]

[available] JacobiSetup.cpp:
[available]     [FormatNumber][53]
[available]     [Jacobi_t::ApplyTopology][234]
[available]     [Jacobi_t::CreateMesh][459]
[available]     [Jacobi_t::InitializeData][552]
[available]     [Jacobi_t::Jacobi_t.cold.30][15]
[available]     [Jacobi_t::Jacobi_t][1043]
[available]     [Jacobi_t::PrintResults][107]
[available]     [Jacobi_t::~Jacobi_t][167]
[available]     [PrintPerfCounter][34]
[available]     [_GLOBAL__sub_I_JacobiSetup.cpp][8]
[available]     [std::__cxx11::basic_stringbuf<char, std::char_traits<char>, std::allocator
<char> >::~basic_stringbuf][16]
[available]     [std::__cxx11::basic_stringbuf<char, std::char_traits<char>, std::allocator
<char> >::~basic_stringbuf][18]
```

Functions found in each module detected by omnitrace

Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
 $ time .mpirun -np 1 ./Jacobi_hip -g 1 1
real     0m2.115s
```

Dynamic instrumentation

```
 $ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1

 real 1m45.742s
```

Available functions to instrument:

```
 $ mpirun -np 1 omnitrace-instrument -v 1 --simulate --
print-available functions -- ./Jacobi_hip -g 1 1
```

Custom include/exclude functions* with -I or -E, resp. For e.g:

```
 $ mpirun -np 1 omnitrace-instrument -v 1 -I
'Jacobi_t::Run' 'JacobiIteration' -- ./Jacobi_hip -g 1 1
```

Include two functions to instrument

```
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocm_smi64.so.5.0.50403'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocmtools.so.1.5.0'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocprofiler64.so.1.0.50403'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/libroctracer64.so.4.1.0'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/libroctx64.so.4.1.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-dl.so.1.8.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-rt.so.11.0.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-user.so.1.8.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libcommon.so.11.0.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libdw-0.182.so'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libelf-0.182.so'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libgotcha.so.2.0.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libpfm.so.4.11.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libtbb.so.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libtbbmalloc.so.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libtbbmalloc_proxy.so.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libunwind.so.99.0.0'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/ld-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libBrokenLocale-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libanl-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libc-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libcrypt.so.1.1.0'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libdl-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libgcc_s-8-20210514.so.1'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_compat-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_dns-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_files-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libpthread-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libresolv-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/librt-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libstdc++.so.6.0.25'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libthread_db-1.0.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.257 sec and 66.740 MB
[omnitrace][exe] Processing 72 modules...
[omnitrace][exe] Processing 72 modules... Done (0.089 sec, 11.080 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip'. Enabling MPI support...
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe]    1 instrumented funcs in JacobiIteration.cpp
[omnitrace][exe]    1 instrumented funcs in JacobiRun.cpp
[omnitrace][exe]    1 instrumented funcs in Jacobi_hip
[omnitrace][exe]    1 instrumented funcs in libamdhip64.so.5.4.50403
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_12.40/instrumentation/overlapping.txt'... Done
```

Only these two functions are shown to be instrumented

Dynamic Instrumentation

Binary Rewrite

Binary Rewrite – Jacobi Example

Binary Rewrite

```
$ omnitrace-instrument [omnitrace-options] -o <new-name-of-exec> -- <CMD> <ARGS>
```

Generating a new executable/library with instrumentation built-in:

```
$ omnitrace-instrument -o Jacobi_hip.inst -- ./Jacobi_hip
```

This new binary will have instrumented functions

Subroutine Instrumentation

Default instrumentation is main function and functions of 1024 instructions and more (for CPU)

To instrument routines with 50 or more cycles, add option "-i 50" (more overhead)

```
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libgcc_s-8-20210514.so.1'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_compat-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_dns-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_files-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libpthread-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libresolv-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/librt-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libstdc++.so.6.0.25'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libthread_db-1.0.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.666 sec and 110.500 MB
[omnitrace][exe] Processing 9 modules...
[omnitrace][exe] Processing 9 modules... Done (0.001 sec, 0.000 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip'. Enabling MPI support...
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_12.57/instrumentation/overlapping.txt'... Done
[omnitrace][exe]
[omnitrace][exe] The instrumented executable image is stored in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip.inst'
[omnitrace][exe] Getting linked libraries for /home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip...
[omnitrace][exe] Consider instrumenting the relevant libraries...
[omnitrace][exe]
[omnitrace][exe]        /lib64/libgcc_s.so.1
[omnitrace][exe]        /lib64/libpthread.so.0
[omnitrace][exe]        /lib64/libm.so.6
[omnitrace][exe]        /lib64/librt.so.1
[omnitrace][exe]        /home/ssitaram/cp2k-hip/libs/install/openmpi/lib/libmpi.so.40
[omnitrace][exe]        /opt/rocm-5.4.3//lib/libroctx64.so.4
[omnitrace][exe]        /opt/rocm-5.4.3//lib/libroctracer64.so.4
[omnitrace][exe]        /opt/rocm-5.4.3/hip/lib/libamdhip64.so.5
[omnitrace][exe]        /lib64/libstdc++.so.6
[omnitrace][exe]        /lib64/libc.so.6
[omnitrace][exe]        /lib64/ld-linux-x86-64.so.2
```

Path to new instrumented binary

Binary Rewrite – Jacobi Example

Binary Rewrite

```
$ omnitrace-instrument [omnitrace-options] -o <new-name-of-exec> -- <CMD> <ARGS>
```

Generating a new /library with instrumentation built-in:

```
$ omnitrace-instrument -o Jacobi_hip.inst -- ./Jacobi_hip
```

Run the instrumented binary:

```
$ mpirun -np 1 omnitrace-run -- ./Jacobi_hip.inst -g 1 1
```

subroutine instrumentation

Default instrumentation is main function and functions of 1024 instructions and more (for CPU)

To instrument routines with 50 or more cycles, add option "`-i 50`" (more overhead)

Binary rewrite is recommended for runs with multiple ranks as omnitrace produces separate output files for each rank

```
[omnitrace][3624331][omnitrace_init_tooling] Instrumentation mode: Trace

    omnitrace v1.8.0
[953.765]       perfetto.cc:58656 Configured tracing session 1, #sources:1, duration:0 ms, #buffers:1, total buffer size:1024000 KB, total sessions:1, uid:0 session name: ""
Topology size: 1 x 1
Local domain size (current node): 4096 x 4096
[omnitrace][0][pid=3624331] MPI rank: 0 (0), MPI size: 1 (1)
Global domain size (all nodes): 4096 x 4096
Rank 0 selecting device 0 on host TheraC60
Starting Jacobi run.
Iteration:    0 - Residual: 0.022108
Iteration:  100 - Residual: 0.000625
Iteration:  200 - Residual: 0.000371
Iteration:  300 - Residual: 0.000274
Iteration:  400 - Residual: 0.000221
Iteration:  500 - Residual: 0.000187
Iteration:  600 - Residual: 0.000163
Iteration:  700 - Residual: 0.000145
Iteration:  800 - Residual: 0.000131
Iteration:  900 - Residual: 0.000120
Iteration: 1000 - Residual: 0.000111
Stopped after 1000 iterations with residue 0.000111
Total Jacobi run time: 1.5470 sec.
Measured lattice updates: 10.84 GLU/s (total), 10.84 GLU/s (per process)
Measured FLOPS: 184.36 GFLOPS (total), 184.36 GFLOPS (per process)
Measured device bandwidth: 1.04 TB/s (total), 1.04 TB/s (per process)

[omnitrace][3624331][0][omnitrace_finalize] finalizing...
[omnitrace][3624331][0][omnitrace_finalize]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331 : 2.364423 sec wall_clock,  645.964 MB peak_rss,
  388.739 MB page_rss, 4.330000 sec cpu_clock,  183.1 % cpu_util [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331/thread/0 : 2.355893 sec wall_clock, 1.293230 sec
 thread_cpu_clock,   54.9 % thread_cpu_util,  645.964 MB peak_rss [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331/thread/1 : 2.345084 sec wall_clock, 0.000261 sec
 thread_cpu_clock,    0.0 % thread_cpu_util,  642.676 MB peak_rss [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize]
[omnitrace][3624331][0][omnitrace_finalize] Finalizing perfetto...
```

Generates traces for application run

List of Instrumented GPU Functions

```
$ cat omnitrace-Jacobi_hip.inst-output/2023-03-15_13.57/roctracer-0.txt
```

ROCM TRACER (ACTIVITY API)

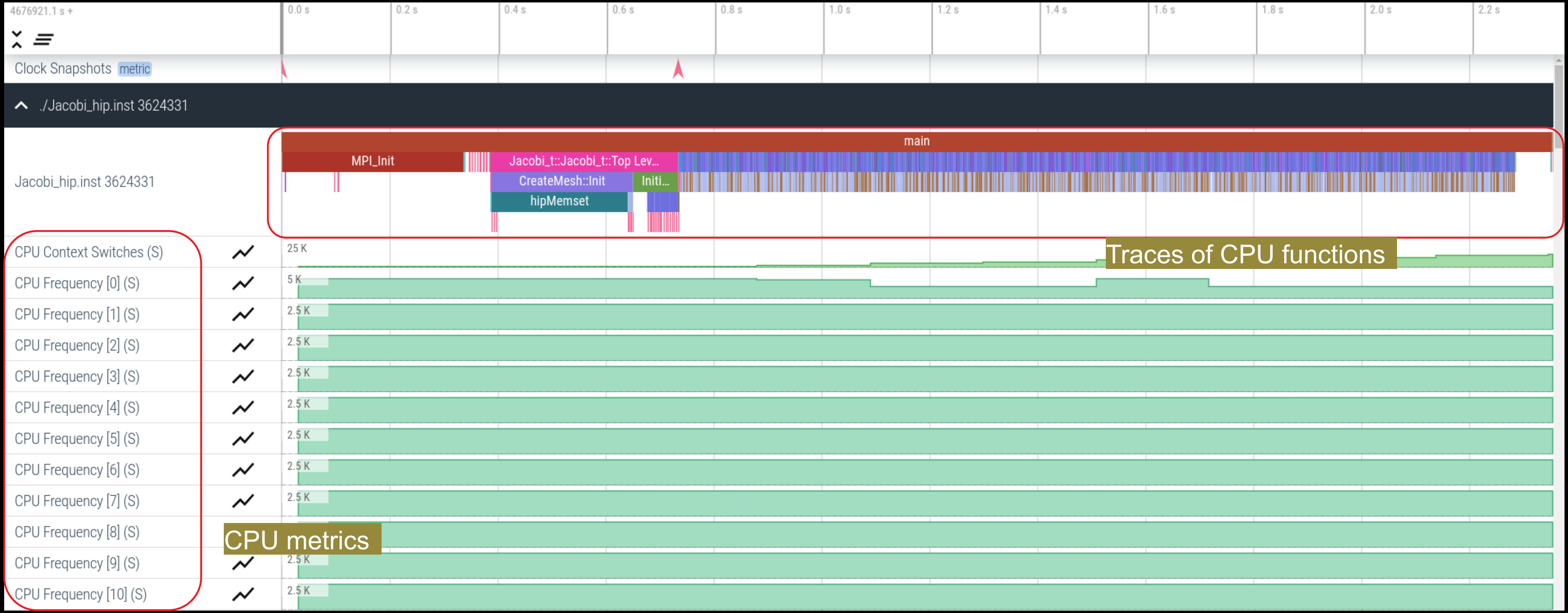
LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	% SELF
|0>>> pthread_create	1	0	roctracer	sec	0.000353	0.000353	0.0
|1>>> |_start_thread	1	1	roctracer	sec	2.344864	2.344864	100.0
|0>>> hipInit	1	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipGetDeviceCount	1	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipSetDevice	1	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipHostMalloc	3	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipMalloc	7	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipMemset	1	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipStreamCreate	2	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipMemcpy	1005	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> |_LocalLaplacianKernel(int, int, int, double, double, double const*, double*)	999	1	roctracer	sec	0.279368	0.000280	100.0
|0>>> |_HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*)	990	1	roctracer	sec	0.014761	0.000015	100.0
|0>>> |_JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)	959	1	roctracer	sec	0.531156	0.000554	100.0
|0>>> |_NormKernel1(int, double, double, double const*, double*)	997	1	roctracer	sec	0.430196	0.000431	100.0
|0>>> |_NormKernel2(int, double const*, double*)	999	1	roctracer	sec	0.004342	0.000004	100.0
|0>>> hipEventCreate	2	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipLaunchKernel	5002	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> |_JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)	1	1	roctracer	sec	0.000552	0.000552	100.0
|0>>> |_NormKernel1(int, double, double, double const*, double*)	1	1	roctracer	sec	0.000425	0.000425	100.0
|0>>> hipDeviceSynchronize	1001	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> |_NormKernel1(int, double, double, double const*, double*)	2	1	roctracer	sec	0.000850	0.000425	100.0
|0>>> |_NormKernel2(int, double const*, double*)	1	1	roctracer	sec	0.000004	0.000004	100.0
|0>>> |_HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*)	9	1	roctracer	sec	0.000133	0.000015	100.0
|0>>> |_JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)	40	1	roctracer	sec	0.022204	0.000555	100.0
|0>>> |_LocalLaplacianKernel(int, int, int, double, double, double const*, double*)	1	1	roctracer	sec	0.000281	0.000281	100.0
|0>>> hipEventRecord	2000	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipStreamSynchronize	2000	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipEventElapsedTime	1000	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> |_HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*)	1	1	roctracer	sec	0.000015	0.000015	100.0
|0>>> hipFree	4	0	roctracer	sec	0.000000	0.000000	0.0
|0>>> hipHostFree	2	0	roctracer	sec	0.000000	0.000000	0.0

Roctracer-0.txt shows duration of HIP API calls and GPU kernels

Visualizing Trace

Use Perfetto

Copy `perfetto-trace-0.proto` to your laptop, go to https://ui.perfetto.dev/, Click "Open trace file", select perfetto-trace-0.proto



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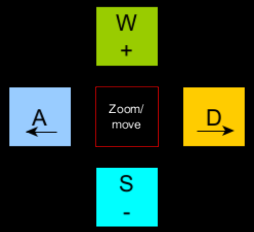
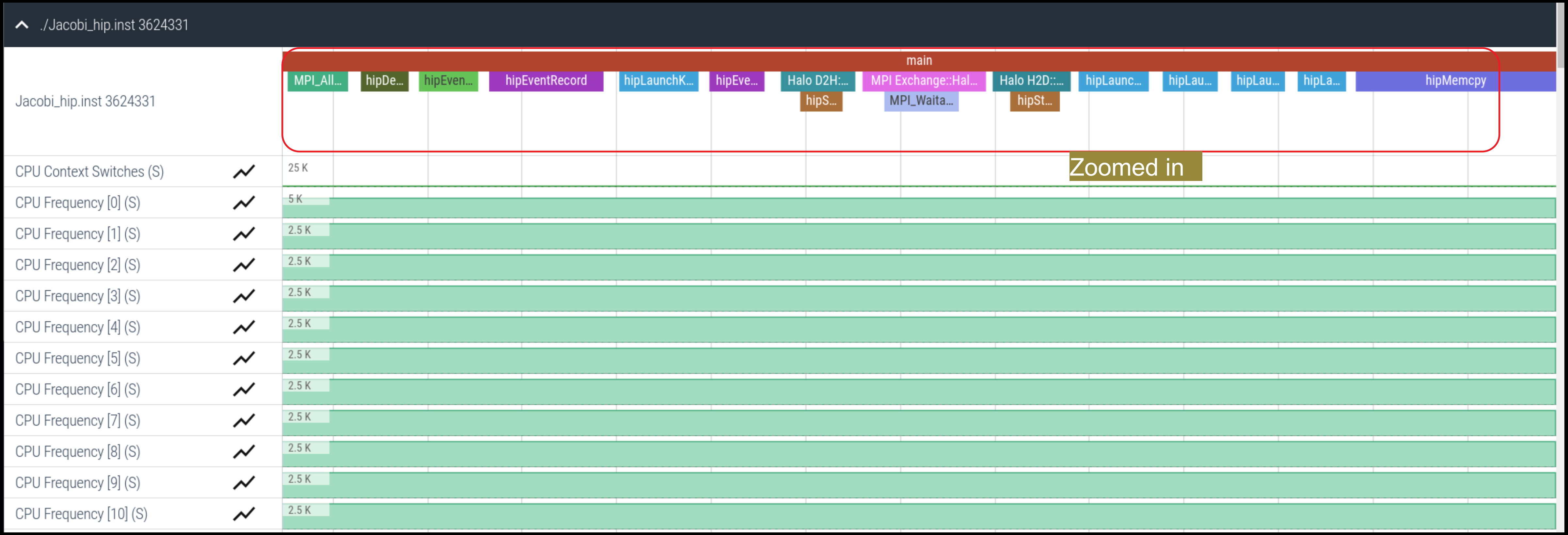
Visualizing Trace



Use Perfetto

Zoom in to investigate regions of interest



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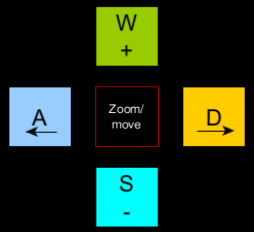
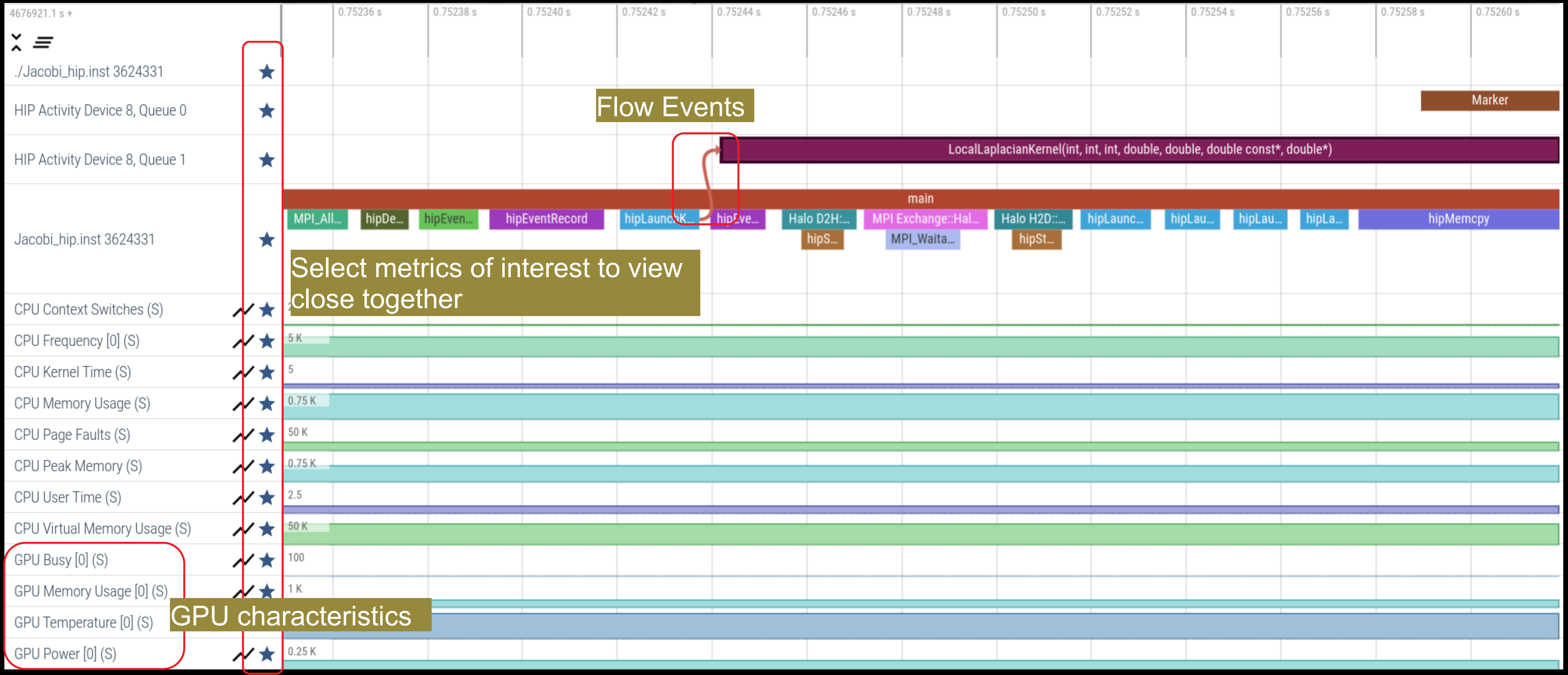
Visualizing Trace

Use Perfetto

Zoom in to investigate regions of interest





Hardware Counters

Hardware Counters – List All

```
$ mpirun -np 1 omnitrace-avail --all
```

Components, Categories

COMPONENT	AVAILABLE	VALUE_TYPE	STRING_IDS	FILENAME	DESCRIPTION	CATEGORY
allinea_map	false	void	"allinea", "allinea_map", "forge"		Controls the AllineaMAP sampler.	category::external, os::supports_linux, t...
caliper_marker	false	void	"cali", "caliper", "caliper_marker"		Generic forwarding of markers to Caliper ...	category::external, os::supports_unix, tp...
caliper_config	false	void	"caliper_config"		Caliper configuration manager.	category::external, os::supports_unix, tp...
caliper_loop_marker	false	void	"caliper_loop_marker"		Variant of caliper_marker with support fo...	category::external, os::supports_unix, tp...
cpu_clock	true	long	"cpu_clock"	cpu_clock	Total CPU time spent in both user- and ke...	project::timemory, category::timing, os::...
cpu_util	true	std::pair<long, long>	"cpu_util", "cpu_utilization"	cpu_util	Percentage of CPU-clock time divided by w...	project::timemory, category::timing, os::...
craypat_counters	false	std::vector<unsigned long, std::allocato...	"craypat_counters"	craypat_counters	Names and value of any counter events tha...	category::external, os::supports_linux, t...

ENVIRONMENT VARIABLE	VALUE	DATA TYPE	DESCRIPTION	CATEGORIES
OMNITRACE_CAUSAL_BINARY_EXCLUDE		string	Excludes binaries matching the list of pr...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_BINARY_SCOPE	%MAIN%	string	Limits causal experiments to the binaries...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_DELAY	0	double	Length of time to wait (in seconds) befor...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_DURATION	0	double	Length of time to perform causal experime...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_FUNCTION_EXCLUDE		string	Excludes functions matching the list of p...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_FUNCTION_SCOPE		string	List of <function> regex entries for caus...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_RANDOM_SEED	0	unsigned long	Seed for random number generator which se...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_SOURCE_EXCLUDE		string	Excludes source files or source file + li...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_SOURCE_SCOPE		string	Limits causal experiments to the source f...	analysis, causal, custom, libomnitrace, o...

Environment Variables

HARDWARE COUNTER	AVAILABLE	DESCRIPTION
CPU		
PAPI_L1_DCM	true	Level 1 data cache misses
PAPI_L1_ICM	false	Level 1 instruction cache misses
PAPI_L2_DCM	true	Level 2 data cache misses
PAPI_L2_ICM	true	Level 2 instruction cache misses
PAPI_L3_DCM	false	Level 3 data cache misses
PAPI_L3_ICM	false	Level 3 instruction cache misses
PAPI_L1_TCM		Level 1 cache misses

CPU Hardware Counters

perf::CYCLES	true	PERF_COUNT_HW_CPU_CYCLES
perf::CYCLES:u=0	true	perf::CYCLES + monitor at user level
perf::CYCLES:k=0	true	perf::CYCLES + monitor at kernel level
perf::CYCLES:h=0	true	perf::CYCLES + monitor at hypervisor level
perf::CYCLES:period=0	true	perf::CYCLES + sampling period
perf::CYCLES:freq=0	true	perf::CYCLES + sampling frequency (Hz)
perf::CYCLES:precise=0	true	perf::CYCLES + precise event sampling
perf::CYCLES:excl=0	true	perf::CYCLES + exclusive access

TCC_NORMAL_WRITEBACK_sum:device=0	true	Number of writebacks due to requests that...
TCC_ALL_TC_OP_WB_WRITEBACK_sum:device=0	true	Number of writebacks due to all TC_OP wri...
TCC_NORMAL_EVICT_sum:device=0	true	Number of evictions due to requests that ...
TCC_ALL_TC_OP_INV_EVICT_sum:device=0	true	Number of evictions due to all TC_OP inva...
TCC_EA_RDREQ_DRAM_sum:device=0	true	Number of TCC/EA read requests (either 32...
TCC_EA_WRREQ_DRAM_sum:device=0	true	Number of TCC/EA write requests (either 3...
FETCH_SIZE:device=0	true	The total kilobytes fetched from the vide...
WRITE_SIZE:device=0	true	The total kilobytes written to the video ...
WRITE_REQ_32B:device=0	true	The total number of 32-byte effective mem...
GPUBusy:device=0	true	The percentage of time GPU was busy.
Wavefronts:device=0		Total wavefronts.
VALUInsts:device=0		The average number of vector ALU instruct...
SALUInsts:device=0	true	The average number of scalar ALU instruct...
SFetchInsts:device=0	true	The average number of scalar fetch instru...
GDSInsts:device=0	true	The average number of GDS read or GDS wri...
MemUnitBusy:device=0	true	The percentage of GPUTime the memory unit...
ALUStalledByLDS:device=0	true	The percentage of GPUTime ALU units are s...

GPU Hardware Counters

A very small subset of the counters shown here

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Commonly Used GPU Counters

VALUUtilization	The percentage of ALUs active in a wave. Low VALUUtilization is likely due to high divergence or a poorly sized grid
VALUBusy	The percentage of GPUTime vector ALU instructions are processed. Can be thought of as something like compute utilization
FetchSize	The total kilobytes fetched from global memory
WriteSize	The total kilobytes written to global memory
L2CacheHit	The percentage of fetch, write, atomic, and other instructions that hit the data in L2 cache
MemUnitBusy	The percentage of GPUTime the memory unit is active. The result includes the stall time
MemUnitStalled	The percentage of GPUTime the memory unit is stalled
WriteUnitStalled	The percentage of GPUTime the write unit is stalled

Full list at: https://github.com/ROCm-Developer-Tools/rocprofiler/blob/amd-master/test/tool/metrics.xml

Modify config file

Create a config file in $HOME:

```
$ omnitrace-avail -G $HOME/.omnitrace.cfg
```

Modify the config file $HOME/.omnitrace.cfg to add desired metrics and for concerned GPU#ID:

```
…
OMNITRACE_ROCM_EVENTS = GPUBusy:device=0,
Wavefronts:device=0, MemUnitBusy:device=0
…
```

To profile desired metrics for all participating GPUs:

```
…
OMNITRACE_ROCM_EVENTS = GPUBusy, Wavefronts,
MemUnitBusy
…
```

Execution with Hardware Counters

(after modifying cfg file to set up OMNITRACE_ROCM_EVENTS with GPU metrics)

```
$ mpirun -np 1 omnitrace-run -- ./Jacobi_hip.inst -g 1 1
```

```
[omnitrace][501266][0][omnitrace_finalize] Finalizing perfetto...
[omnitrace][501266][perfetto]> Outputting '/shared/prod/home/ssitaram/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_hip-output/2023-03-15_22.57/perfetto-trace-0.proto' (11
.. Done
[omnitrace][501266][rocprof-device-0-GPUBusy]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-GPUBusy-0.json'
[omnitrace][501266][rocprof-device-0-GPUBusy]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-GPUBusy-0.txt'
[omnitrace][501266][rocprof-device-0-Wavefronts]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-Wavefronts-0.json'
[omnitrace][501266][rocprof-device-0-Wavefronts]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-Wavefronts-0.txt'
[omnitrace][501266][rocprof-device-0-MemUnitBusy]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-MemUnitBusy-0.json'
[omnitrace][501266][rocprof-device-0-MemUnitBusy]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/rocprof-device-0-MemUnitBusy-0.txt'
[omnitrace][501266][trip_count]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/trip_count-0.json'
[omnitrace][501266][trip_count]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/trip_count-0.txt'
[omnitrace][501266][wall_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/wall_clock-0.json'
[omnitrace][501266][wall_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/wall_clock-0.txt'
[omnitrace][501266][roctracer]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/roctracer-0.json'
[omnitrace][501266][roctracer]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/roctracer-0.txt'
[omnitrace][501266][sampling_percent]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_percent-0.json'
[omnitrace][501266][sampling_percent]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_percent-0.txt'
[omnitrace][501266][sampling_cpu_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_cpu_clock-0.json'
[omnitrace][501266][sampling_cpu_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_cpu_clock-0.txt'
[omnitrace][501266][sampling_wall_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_wall_clock-0.json'
[omnitrace][501266][sampling_wall_clock]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_wall_clock-0.txt'
[omnitrace][501266][sampling_gpu_memory_usage]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_memory_usage-0.json'
[omnitrace][501266][sampling_gpu_memory_usage]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_memory_usage-0.txt'
[omnitrace][501266][sampling_gpu_power]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_power-0.json'
[omnitrace][501266][sampling_gpu_power]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_power-0.txt'
[omnitrace][501266][sampling_gpu_temperature]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_temperature-0.json'
[omnitrace][501266][sampling_gpu_temperature]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_temperature-0.txt'
[omnitrace][501266][sampling_gpu_busy_percent]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_busy_percent-0.json'
[omnitrace][501266][sampling_gpu_busy_percent]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/sampling_gpu_busy_percent-0.txt'
[omnitrace][501266][metadata]> Outputting 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/metadata-0.json' and 'omnitrace-Jacobi_hip-output/2023-03-15_22.57/functions-0.json'
[omnitrace][501266][0][omnitrace_finalize] Finalized: 31.657272 sec wall_clock,    0.000 MB peak_rss,  179.700 MB page_rss, 29.950000 sec cpu_clock,   94.6 % cpu_util
[889.832]       perfetto.cc:60129 Tracing session 1 ended, total sessions:0
```

GPU hardware counters

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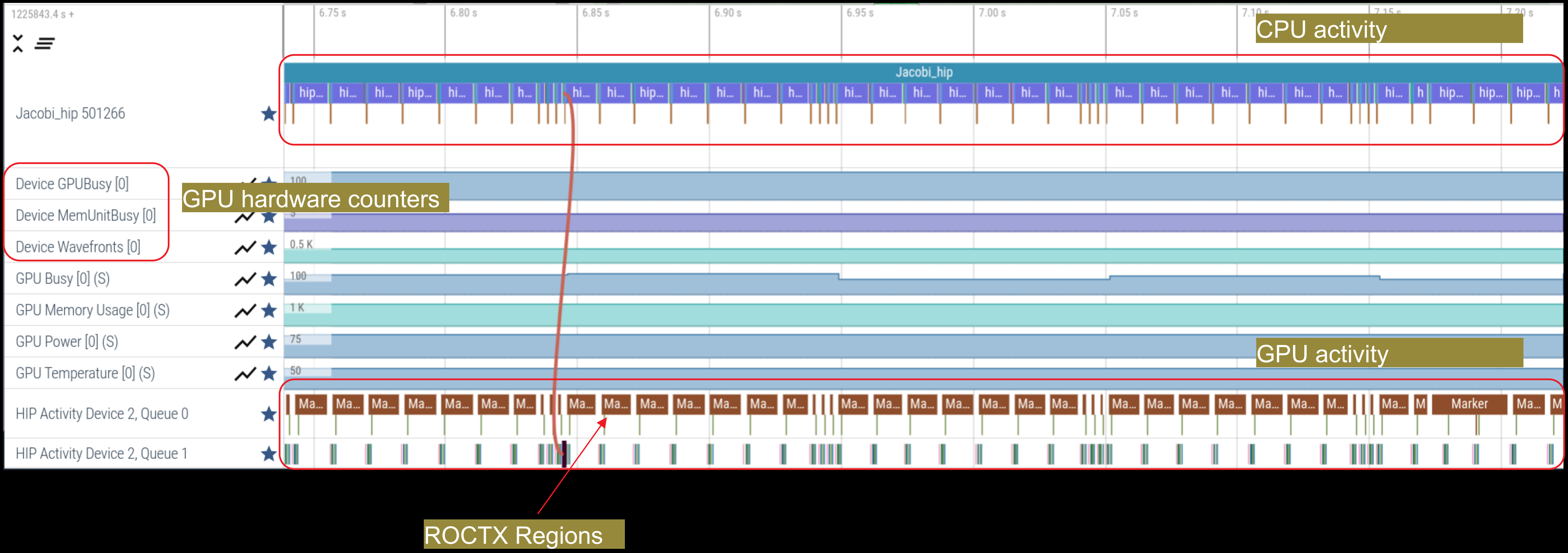
Visualization with Hardware Counters



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Tracing Multiple Ranks

Profiling Multiple MPI Ranks – Jacobi Example

Binary Rewrite

Generating a new /library with instrumentation built-in:

```
 $ omnitrace-instrument -o Jacobi_hip.inst --
./Jacobi_hip
```

Run the instrumented binary with 2 ranks:

```
 $ mpirun -np 2 omnitrace-run --./Jacobi_hip.inst -g
2 1
```

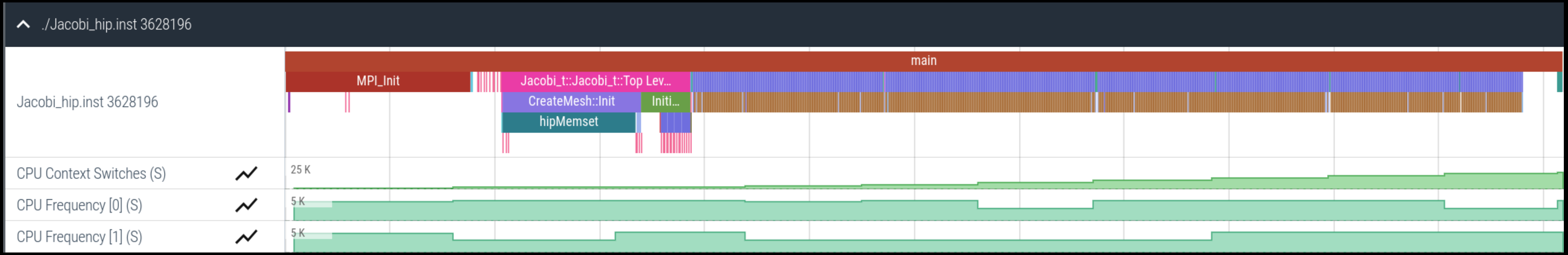
```
[omnitrace][3628199][perfetto]> Outputting '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/perfetto-trace-1.proto'
[perfetto]> Outputting '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/perfetto-trace-0.proto' (7856.71 KB / 7.86 M

[omnitrace][3628199][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-1.json'
[omnitrace][3628196][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-0.json'
[omnitrace][3628199][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-1.txt'
[omnitrace][3628196][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-0.txt'
```

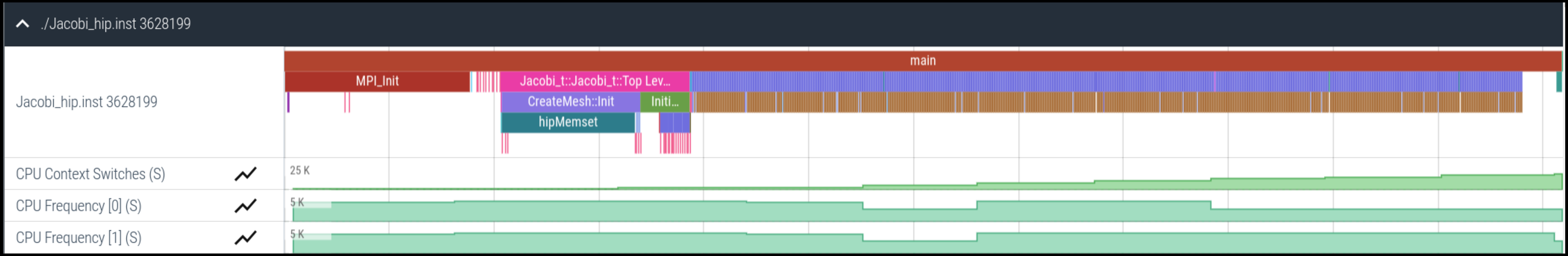
All output files are generated for each rank

Visualizing Traces from Multiple Ranks - Separately

MPI 0



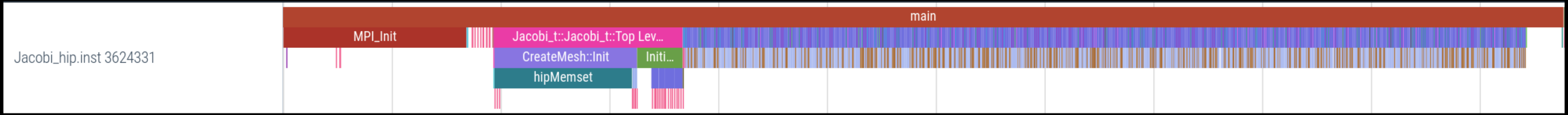
MPI 1



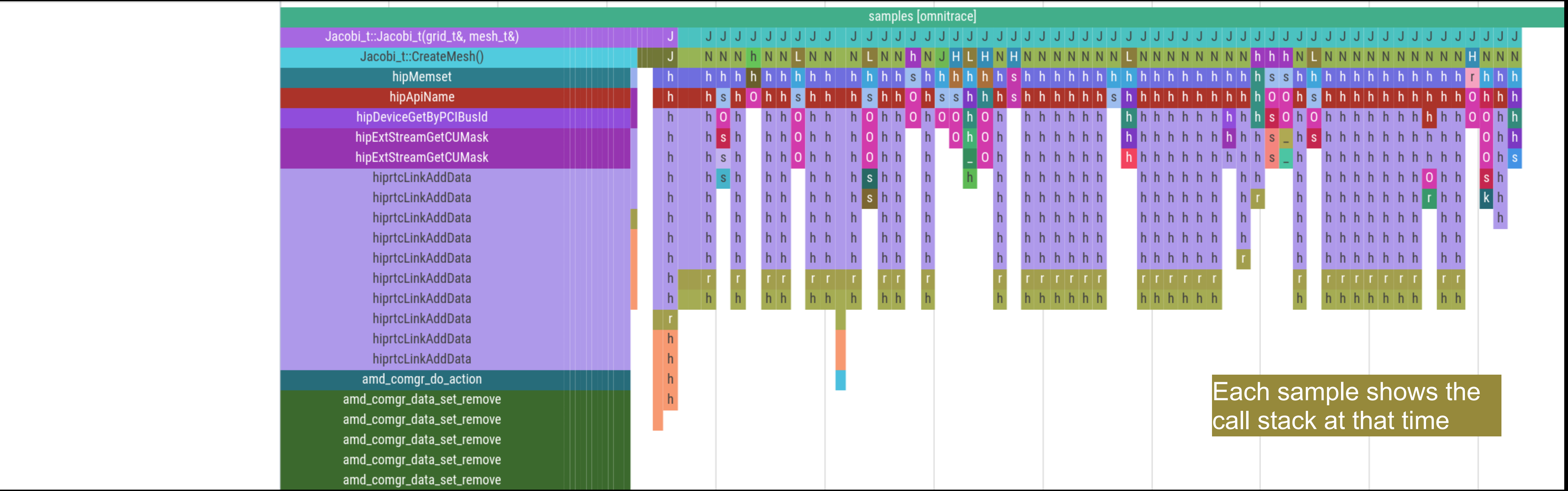
Statistical Sampling

Sampling Call-Stack (I)

`OMNITRACE_USE_SAMPLING = false`



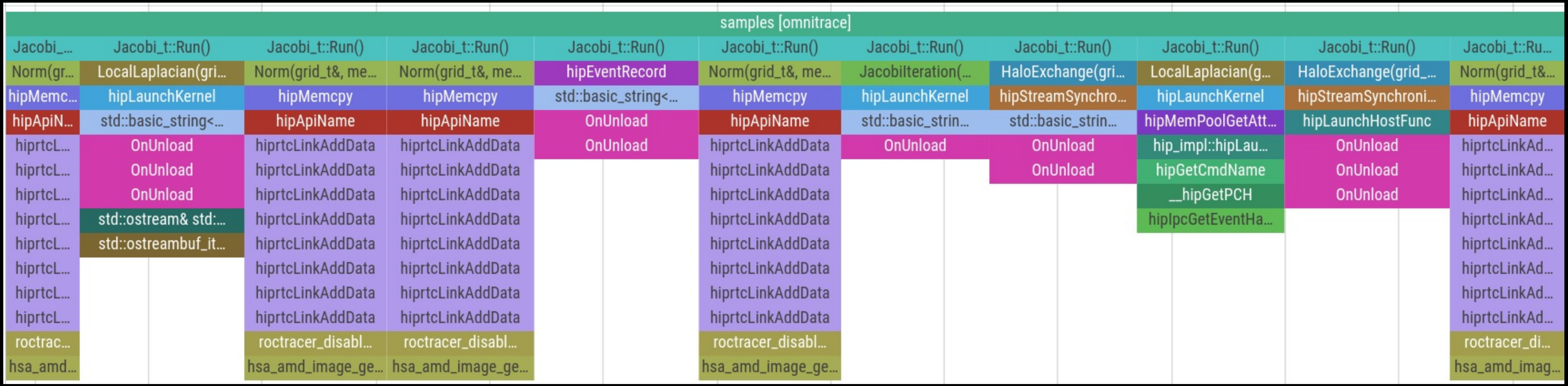
`OMNITRACE_USE_SAMPLING = true; OMNITRACE_SAMPLING_FREQ = 100` (100 samples per second)



Scroll down all the way in Perfetto to see the sampling output!

Sampling Call-Stack (II)

Zoom in call-stack sampling



Thread 0 (S) 3625610

Sampling data is annotated with (S)

Other Features

Kernel Durations

```
$ cat omnitrace-Jacobi_hip.inst-output/2023-03-15_13.57/wall_clock-0.txt
```

If you do not see a wall_clock.txt dumped by omnitrace, try modify the config file `$HOME/.omnitrace.cfg` and enable `OMNITRACE_USE_TIMEMORY`:

```
…
OMNITRACE_USE_PERFETTO                         = true
OMNITRACE_USE_TIMEMORY                         = true
OMNITRACE_USE_SAMPLING                         = false
…
```

Durations

Call Stack

```
| |0>>>       |_MPI_Allreduce                                                             | 1 |  5 | wall_clock | sec | 0.000012 | 0.000012 | 0.000012 | 0.000012 | 0.000000 | 0.000000 | 100.0 |
| |0>>>       |_hipDeviceSynchronize                                                      | 1 |  5 | wall_clock | sec | 0.000019 | 0.000019 | 0.000019 | 0.000019 | 0.000000 | 0.000000 |  94.4 |
| |0>>>         |_NormKernel1(int, double, double, double const*, double*)                | 1 |  6 | wall_clock | sec | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.000000 | 0.000000 | 100.0 |
| |0>>>         |_NormKernel2(int, double const*, double*)                                | 1 |  6 | wall_clock | sec | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 100.0 |
| |0>>>       |_MPI_Barrier                                                               | 1 |  5 | wall_clock | sec | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.000000 | 0.000000 | 100.0 |
| |0>>>       |_hipEventRecord                                                            | 2 |  5 | wall_clock | sec | 0.000027 | 0.000014 | 0.000011 | 0.000016 | 0.000000 | 0.000003 | 100.0 |
| |0>>>       |_Halo D2H::Halo Exchange                                                   | 1 |  5 | wall_clock | sec | 1.628420 | 1.628420 | 1.628420 | 1.628420 | 0.000000 | 0.000000 |   0.0 |
| |0>>>         |_hipStreamSynchronize                                                    | 1 |  6 | wall_clock | sec | 0.000003 | 0.000003 | 0.000003 | 0.000003 | 0.000000 | 0.000000 | 100.0 |
| |0>>>         |_MPI Exchange::Halo Exchange                                             | 1 |  6 | wall_clock | sec | 1.628395 | 1.628395 | 1.628395 | 1.628395 | 0.000000 | 0.000000 |   0.0 |
| |0>>>           |_MPI_Waitall                                                           | 1 |  7 | wall_clock | sec | 0.000002 | 0.000002 | 0.000002 | 0.000002 | 0.000000 | 0.000000 | 100.0 |
| |0>>>           |_Halo H2D::Halo Exchange                                               | 1 |  7 | wall_clock | sec | 1.628104 | 1.628104 | 1.628104 | 1.628104 | 0.000000 | 0.000000 |   0.0 |
| |0>>>             |_hipStreamSynchronize                                                | 1 |  8 | wall_clock | sec | 0.000003 | 0.000003 | 0.000003 | 0.000003 | 0.000000 | 0.000000 | 100.0 |
| |0>>>             |_hipLaunchKernel                                                     | 5 |  8 | wall_clock | sec | 0.000615 | 0.000123 | 0.000005 | 0.000578 | 0.000000 | 0.000254 |  99.6 |
| |0>>>               |_mbind                                                             | 1 |  9 | wall_clock | sec | 0.000003 | 0.000003 | 0.000003 | 0.000003 | 0.000000 | 0.000000 | 100.0 |
| |0>>>             |_hipMemcpy                                                           | 1 |  8 | wall_clock | sec | 0.001122 | 0.001122 | 0.001122 | 0.001122 | 0.000000 | 0.000000 |  99.9 |
| |0>>>               |_LocalLaplacianKernel(int, int, int, double, double, double const*, double*)  | 1 |  9 | wall_clock | sec | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 100.0 |
| |0>>>               |_HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*) | 1 |  9 | wall_clock | sec | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 100.0 |
| |0>>>               |_JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*) | 1 |  9 | wall_clock | sec | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 100.0 |
```

Text file is for quick reference. JSON output is easy to script for and can be read by Hatchet, a Python package (https://hatchet.readthedocs.io/en/latest/)

Kernel Durations (flat profile)

Edit in your omnitrace.cfg:

```
OMNITRACE_USE_TIMEMORY        = true
OMNITRACE_FLAT_PROFILE        = true
```

Use flat profile to see aggregate duration of kernels and functions

REAL-CLOCK TIMER (I.E. WALL-CLOCK TIMER)

LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	MIN	MAX	VAR	STDDEV	% SELF
|0>>> main	1	0	wall_clock	sec	82.739099	82.739099	82.739099	82.739099	0.000000	0.000000	100.0
|0>>> MPI_Init	1	0	wall_clock	sec	34.056610	34.056610	34.056610	34.056610	0.000000	0.000000	100.0
|0>>> pthread_create	3	0	wall_clock	sec	0.014644	0.004881	0.001169	0.011974	0.000038	0.006145	100.0
|0>>> mbind	285	0	wall_clock	sec	0.001793	0.000006	0.000005	0.000020	0.000000	0.000002	100.0
|0>>> MPI_Comm_dup	1	0	wall_clock	sec	0.000212	0.000212	0.000212	0.000212	0.000000	0.000000	100.0
|0>>> MPI_Comm_rank	1	0	wall_clock	sec	0.000041	0.000041	0.000041	0.000041	0.000000	0.000000	100.0
|0>>> MPI_Comm_size	1	0	wall_clock	sec	0.000004	0.000004	0.000004	0.000004	0.000000	0.000000	100.0
|0>>> hipInit	1	0	wall_clock	sec	0.000372	0.000372	0.000372	0.000372	0.000000	0.000000	100.0
|0>>> hipGetDeviceCount	1	0	wall_clock	sec	0.000017	0.000017	0.000017	0.000017	0.000000	0.000000	100.0
|0>>> MPI_Allgather	1	0	wall_clock	sec	0.000009	0.000009	0.000009	0.000009	0.000000	0.000000	100.0
|0>>> hipSetDevice	1	0	wall_clock	sec	0.000024	0.000024	0.000024	0.000024	0.000000	0.000000	100.0
|0>>> hipHostMalloc	3	0	wall_clock	sec	0.126827	0.042276	0.000176	0.126453	0.005314	0.072900	100.0
|0>>> hipMalloc	7	0	wall_clock	sec	0.000458	0.000065	0.000024	0.000178	0.000000	0.000052	100.0
|0>>> hipMemset	1	0	wall_clock	sec	35.770403	35.770403	35.770403	35.770403	0.000000	0.000000	100.0
|0>>> hipStreamCreate	2	0	wall_clock	sec	0.016750	0.008375	0.005339	0.011412	0.000018	0.004295	100.0
|0>>> hipMemcpy	1005	0	wall_clock	sec	8.506781	0.008464	0.000610	0.039390	0.000023	0.004844	100.0
|0>>> hipEventCreate	2	0	wall_clock	sec	0.000037	0.000018	0.000016	0.000021	0.000000	0.000003	100.0
|0>>> hipLaunchKernel	5002	0	wall_clock	sec	0.181301	0.000036	0.000025	0.012046	0.000000	0.000278	100.0
|0>>> MPI_Allreduce	1003	0	wall_clock	sec	0.002009	0.000002	0.000001	0.000022	0.000000	0.000001	100.0
|0>>> hipDeviceSynchronize	1001	0	wall_clock	sec	0.016813	0.000017	0.000015	0.000043	0.000000	0.000004	100.0
|0>>> MPI_Barrier	3	0	wall_clock	sec	0.000007	0.000002	0.000001	0.000004	0.000000	0.000001	100.0
|0>>> hipEventRecord	2000	0	wall_clock	sec	0.046701	0.000023	0.000020	0.000225	0.000000	0.000006	100.0
|0>>> hipStreamSynchronize	2000	0	wall_clock	sec	0.030366	0.000015	0.000013	0.000382	0.000000	0.000009	100.0
|0>>> MPI_Waitall	1000	0	wall_clock	sec	0.001665	0.000002	0.000002	0.000007	0.000000	0.000000	100.0
|0>>> NormKernel1(int, double, double, double const*, double*)	1001	0	wall_clock	sec	0.001502	0.000002	0.000001	0.000006	0.000000	0.000000	100.0
|0>>> NormKernel2(int, double const*, double*)	1000	0	wall_clock	sec	0.001972	0.000002	0.000001	0.000003	0.000000	0.000001	100.0
|0>>> LocalLaplacianKernel(int, int, int, double, double, double const*, double*)	1000	0	wall_clock	sec	0.001488	0.000001	0.000001	0.000007	0.000000	0.000000	100.0
|0>>> HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*)	1000	0	wall_clock	sec	0.001465	0.000001	0.000001	0.000007	0.000000	0.000000	100.0
|0>>> hipEventElapsedTime	1000	0	wall_clock	sec	0.015060	0.000015	0.000014	0.000041	0.000000	0.000002	100.0
|0>>> JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)	1000	0	wall_clock	sec	0.002598	0.000003	0.000001	0.000006	0.000000	0.000001	100.0
|0>>> pthread_join	1	0	wall_clock	sec	0.000396	0.000396	0.000396	0.000396	0.000000	0.000000	100.0
|0>>> hipFree	4	0	wall_clock	sec	0.000526	0.000131	0.000021	0.000243	0.000000	0.000091	100.0
|0>>> hipHostFree	2	0	wall_clock	sec	0.000637	0.000318	0.000287	0.000350	0.000000	0.000044	100.0
|3>>> start_thread	1	0	wall_clock	sec	0.004802	0.004802	0.004802	0.004802	0.000000	0.000000	100.0
|1>>> start_thread	1	0	wall_clock	sec	81.987779	81.987779	81.987779	81.987779	0.000000	0.000000	100.0
|2>>> start_thread	-	0	-	-	-	-	-	-	-	-	-

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User API

Omnitrace provides an API to control the instrumentation

API Call	Description
`int omnitrace_user_start_trace(void)`	Enable tracing on this thread and all subsequently created threads
`int omnitrace_user_stop_trace(void)`	Disable tracing on this thread and all subsequently created threads
`int omnitrace_user_start_thread_trace(void)`	Enable tracing on this specific thread. Does not apply to subsequently created threads
`int omnitrace_user_stop_thread_trace(void)`	Disable tracing on this specific thread. Does not apply to subsequently created threads
`int omnitrace_user_push_region(void)`	Start user defined region
`int omnitrace_user_pop_region(void)`	End user defined region, FILO (first in last out) is expected

All the API calls: https://amdresearch.github.io/omnitrace/user_api.html

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OpenMP®

We use the example omnitrace/examples/openmp/

Build the code with CMake:

```
$ cmake -B build
```

Use the openmp-lu binary, which can be executed with:

```
$ export OMP_NUM_THREADS=4
$ srun -n 1 -c 4 ./openmp-lu
```

Create a new instrumented binary:

```
$ srun -n 1 omnitrace-instrument -o openmp-lu.inst --
./openmp-lu
```

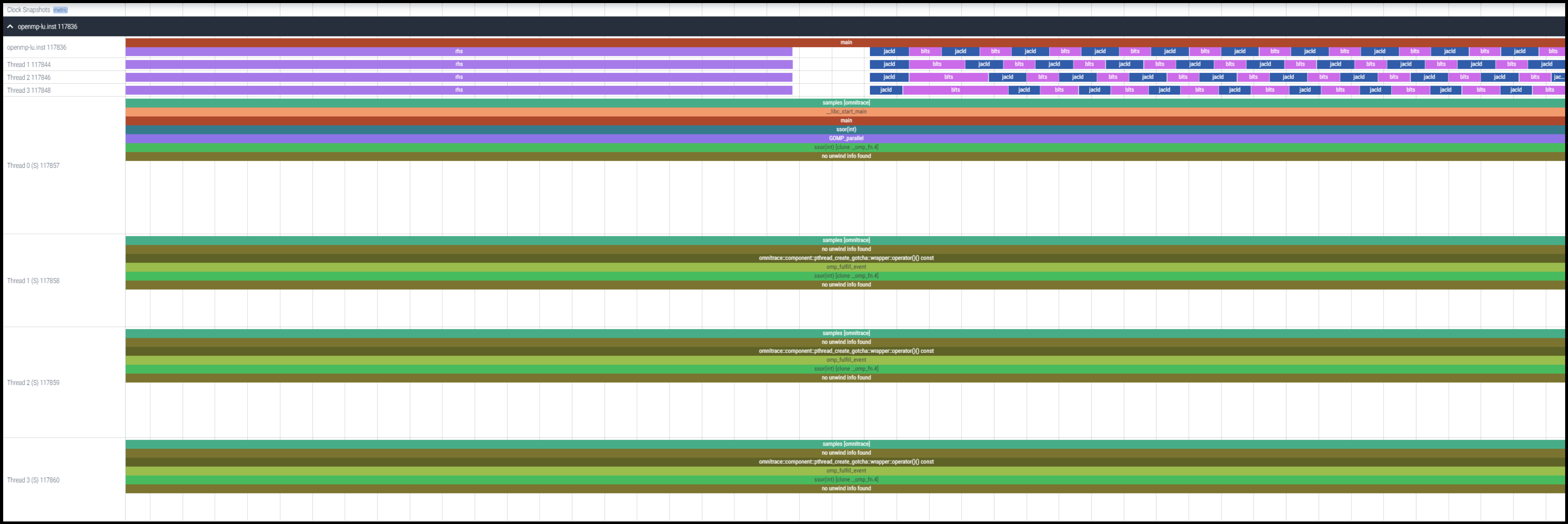
Execute the new binary:

```
$ srun -n 1 -c 4 omnitrace-run -- ./openmp-lu.inst
```

REAL-CLOCK TIMER (I.E. WALL-CLOCK TIMER)

LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	MIN	MAX	VAR	STDDEV	% SELF
|0>>> main	1	0	wall_clock	sec	1.096702	1.096702	1.096702	1.096702	0.000000	0.000000	9.2
|0>>> |_pthread_create	3	1	wall_clock	sec	0.002931	0.000977	0.000733	0.001420	0.000000	0.000385	0.0
|3>>> |_start_thread	1	2	wall_clock	sec	2.451520	2.451520	2.451520	2.451520	0.000000	0.000000	57.7
|3>>> |_erhs	1	3	wall_clock	sec	0.001906	0.001906	0.001906	0.001906	0.000000	0.000000	100.0
|3>>> |_rhs	153	3	wall_clock	sec	0.229893	0.001503	0.001410	0.001893	0.000000	0.000116	100.0
|3>>> |_jacld	3473	3	wall_clock	sec	0.170568	0.000049	0.000047	0.000135	0.000000	0.000005	100.0
|3>>> |_blts	3473	3	wall_clock	sec	0.232512	0.000067	0.000040	0.000959	0.000000	0.000034	100.0
|3>>> |_jacu	3473	3	wall_clock	sec	0.166229	0.000048	0.000046	0.000148	0.000000	0.000005	100.0
|3>>> |_buts	3473	3	wall_clock	sec	0.236484	0.000068	0.000041	0.000391	0.000000	0.000031	100.0
|2>>> |_start_thread	1	2	wall_clock	sec	2.452309	2.452309	2.452309	2.452309	0.000000	0.000000	58.1
|2>>> |_erhs	1	3	wall_clock	sec	0.001895	0.001895	0.001895	0.001895	0.000000	0.000000	100.0
|2>>> |_rhs	153	3	wall_clock	sec	0.229776	0.001502	0.001410	0.001893	0.000000	0.000115	100.0
|2>>> |_jacld	3473	3	wall_clock	sec	0.204609	0.000059	0.000057	0.000152	0.000000	0.000006	100.0
|2>>> |_blts	3473	3	wall_clock	sec	0.192986	0.000056	0.000047	0.000358	0.000000	0.000026	100.0
|2>>> |_jacu	3473	3	wall_clock	sec	0.199029	0.000057	0.000055	0.000188	0.000000	0.000007	100.0
|2>>> |_buts	3473	3	wall_clock	sec	0.198972	0.000057	0.000048	0.000372	0.000000	0.000026	100.0
|1>>> |_start_thread	1	2	wall_clock	sec	2.453072	2.453072	2.453072	2.453072	0.000000	0.000000	58.6
|1>>> |_erhs	1	3	wall_clock	sec	0.001905	0.001905	0.001905	0.001905	0.000000	0.000000	100.0
|1>>> |_rhs	153	3	wall_clock	sec	0.229742	0.001502	0.001410	0.001894	0.000000	0.000115	100.0
|1>>> |_jacld	3473	3	wall_clock	sec	0.206418	0.000059	0.000057	0.000934	0.000000	0.000016	100.0
|1>>> |_blts	3473	3	wall_clock	sec	0.186097	0.000054	0.000047	0.000344	0.000000	0.000023	100.0
|1>>> |_jacu	3473	3	wall_clock	sec	0.198689	0.000057	0.000055	0.000186	0.000000	0.000006	100.0
|1>>> |_buts	3473	3	wall_clock	sec	0.192470	0.000055	0.000048	0.000356	0.000000	0.000022	100.0
|0>>> |_erhs	1	1	wall_clock	sec	0.001961	0.001961	0.001961	0.001961	0.000000	0.000000	100.0
|0>>> |_rhs	153	1	wall_clock	sec	0.229889	0.001503	0.001410	0.001891	0.000000	0.000116	100.0
|0>>> |_jacld	3473	1	wall_clock	sec	0.208903	0.000060	0.000057	0.000359	0.000000	0.000017	100.0
|0>>> |_blts	3473	1	wall_clock	sec	0.172646	0.000050	0.000047	0.000822	0.000000	0.000020	100.0
|0>>> |_jacu	3473	1	wall_clock	sec	0.202130	0.000058	0.000055	0.000350	0.000000	0.000016	100.0
|0>>> |_buts	3473	1	wall_clock	sec	0.176975	0.000051	0.000048	0.000377	0.000000	0.000016	100.0
|0>>> |_pintgr	1	1	wall_clock	sec	0.000054	0.000054	0.000054	0.000054	0.000000	0.000000	100.0

OpenMP® Visualization



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Python™

The omnitrace Python package is installed in /path/omnitrace_install/lib/pythonX.Y/site-packages/omnitrace

Setup the environment:

```
$ export PYTHONPATH=/path/omnitrace/lib/python/site-packages/:${PYTHONPATH}
```

We use the Fibonacci example in omnitrace/examples/python/source.py

Execute the python program with:

```
$ omnitrace-python ./external.py
```

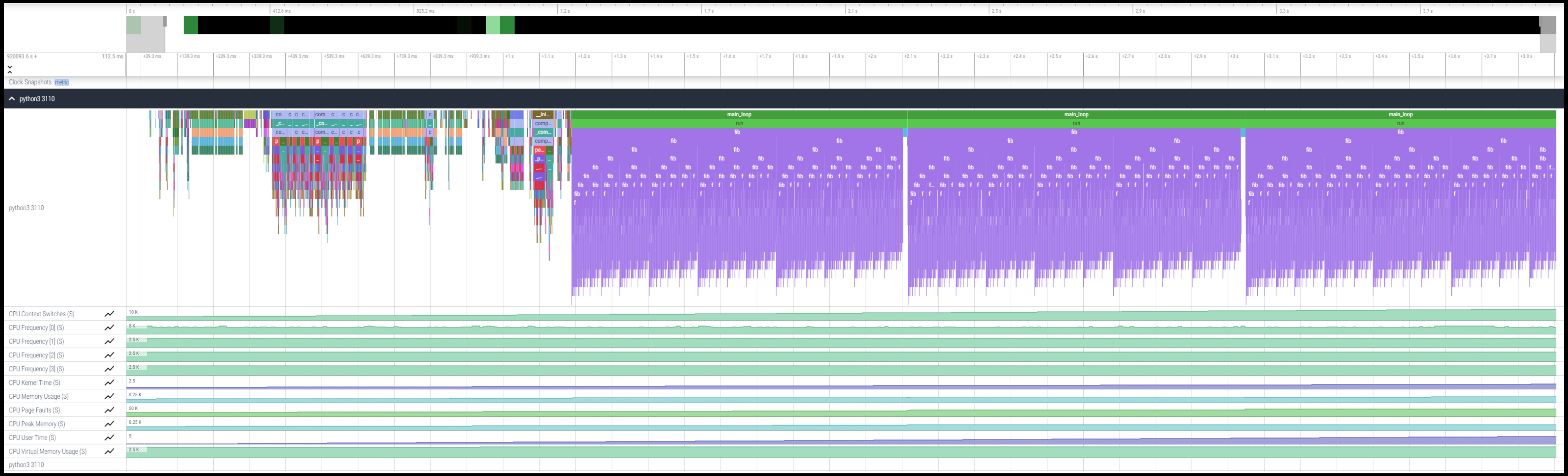
Profiled data is dumped in output directory:

```
$ cat omnitrace-source-output/timestamp/wall_clock.txt
```

```
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                          REAL-CLOCK TIMER (I.E. WALL-CLOCK TIMER)                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   LABEL                          | COUNT  | DEPTH  |   METRIC   | UNITS  |   SUM    |   MEAN   |   MIN    |   MAX    |   VAR    |  STDDEV  | % SELF |
|--------------------------------------------------|--------|--------|------------|--------|----------|----------|----------|----------|----------|----------|--------|
| |0>>> main_loop                                  |      3 |      0 | wall_clock | sec    | 2.786075 | 0.928692 | 0.926350 | 0.932130 | 0.000009 | 0.003042 |    0.0 |
| |0>>> |_run                                      |      3 |      1 | wall_clock | sec    | 2.785799 | 0.928600 | 0.926250 | 0.932037 | 0.000009 | 0.003043 |    0.0 |
| |0>>>   |_fib                                    |      3 |      2 | wall_clock | sec    | 2.750104 | 0.916701 | 0.914454 | 0.919577 | 0.000007 | 0.002619 |    0.0 |
| |0>>>     |_fib                                  |      6 |      3 | wall_clock | sec    | 2.749901 | 0.458317 | 0.348962 | 0.567074 | 0.013958 | 0.118145 |    0.0 |
| |0>>>       |_fib                                |     12 |      4 | wall_clock | sec    | 2.749511 | 0.229126 | 0.133382 | 0.350765 | 0.006504 | 0.080650 |    0.0 |
| |0>>>         |_fib                              |     24 |      5 | wall_clock | sec    | 2.748734 | 0.114531 | 0.050867 | 0.217030 | 0.002399 | 0.048977 |    0.1 |
| |0>>>           |_fib                            |     48 |      6 | wall_clock | sec    | 2.747118 | 0.057232 | 0.019302 | 0.134596 | 0.000806 | 0.028396 |    0.1 |
| |0>>>             |_fib                          |     96 |      7 | wall_clock | sec    | 2.743922 | 0.028583 | 0.007181 | 0.083350 | 0.000257 | 0.016026 |    0.2 |
| |0>>>               |_fib                        |    192 |      8 | wall_clock | sec    | 2.737564 | 0.014258 | 0.002690 | 0.051524 | 0.000079 | 0.008887 |    0.5 |
| |0>>>                 |_fib                      |    384 |      9 | wall_clock | sec    | 2.724966 | 0.007096 | 0.000973 | 0.031798 | 0.000024 | 0.004865 |    0.9 |
| |0>>>                   |_fib                    |    768 |     10 | wall_clock | sec    | 2.699251 | 0.003515 | 0.000336 | 0.019670 | 0.000007 | 0.002637 |    1.9 |
| |0>>>                     |_fib                  |   1536 |     11 | wall_clock | sec    | 2.648006 | 0.001724 | 0.000096 | 0.012081 | 0.000002 | 0.001417 |    3.9 |
| |0>>>                       |_fib                |   3072 |     12 | wall_clock | sec    | 2.545260 | 0.000829 | 0.000016 | 0.007461 | 0.000001 | 0.000758 |    8.0 |
| |0>>>                         |_fib              |   6078 |     13 | wall_clock | sec    | 2.342276 | 0.000385 | 0.000016 | 0.004669 | 0.000000 | 0.000404 |   16.0 |
| |0>>>                           |_fib            |  10896 |     14 | wall_clock | sec    | 1.967475 | 0.000181 | 0.000015 | 0.002752 | 0.000000 | 0.000218 |   28.6 |
| |0>>>                             |_fib          |  15060 |     15 | wall_clock | sec    | 1.404069 | 0.000093 | 0.000015 | 0.001704 | 0.000000 | 0.000123 |   43.6 |
| |0>>>                               |_fib        |  14280 |     16 | wall_clock | sec    | 0.791873 | 0.000055 | 0.000015 | 0.001044 | 0.000000 | 0.000076 |   58.3 |
| |0>>>                                 |_fib      |   8826 |     17 | wall_clock | sec    | 0.330189 | 0.000037 | 0.000015 | 0.000620 | 0.000000 | 0.000050 |   70.9 |
| |0>>>                                   |_fib    |   3456 |     18 | wall_clock | sec    | 0.096120 | 0.000028 | 0.000015 | 0.000380 | 0.000000 | 0.000034 |   81.0 |
| |0>>>                                     |_fib  |    822 |     19 | wall_clock | sec    | 0.018294 | 0.000022 | 0.000015 | 0.000209 | 0.000000 | 0.000024 |   88.9 |
| |0>>>                                       |_fib|    108 |     20 | wall_clock | sec    | 0.002037 | 0.000019 | 0.000016 | 0.000107 | 0.000000 | 0.000015 |   94.9 |
| |0>>>                                        |_fib|     6 |     21 | wall_clock | sec    | 0.000104 | 0.000017 | 0.000016 | 0.000019 | 0.000000 | 0.000001 |  100.0 |
| |0>>>   |_inefficient                            |      3 |      2 | wall_clock | sec    | 0.035450 | 0.011817 | 0.010096 | 0.012972 | 0.000002 | 0.001519 |   95.8 |
| |0>>>     |__sum                                 |      3 |      3 | wall_clock | sec    | 0.001494 | 0.000498 | 0.000440 | 0.000537 | 0.000000 | 0.000051 |  100.0 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
```

Python documentation: https://amdresearch.github.io/omnitrace/python.html

Visualizing Python™ Perfetto Tracing



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Kokkos

Omnitrace can instrument Kokkos applications too.

Edit the $HOME/.omnitrace.cfg file and enable omnitrace:

```
...
OMNITRACE_USE_KOKKOSP = true
...
```

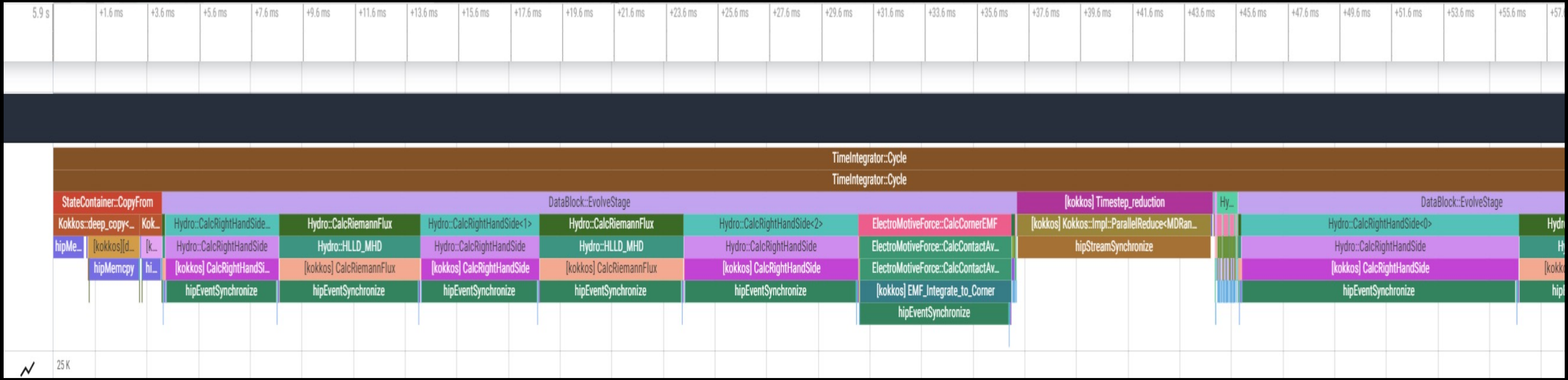
Profiling with omnitrace produces *kokkos*.txt files:

```
$ cat kokkos_memory0.txt
```

```
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>   |_[kokkos][deep_copy] Host=DataBlock_A2_mirror HIP=DataBlock_A2                                 |     1 |     2 | kokkos_memory | MB     |  142 |  142 |  100 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check    |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check          |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>   |_[kokkos][deep_copy] Host=DataBlock_dV_mirror HIP=DataBlock_dV                                 |     1 |     2 | kokkos_memory | MB     |  140 |  140 |  100 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check    |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check          |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>> |_DataBlockHost::SyncToDevice()                                                                 |     1 |     1 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>   |_[kokkos][deep_copy] HIP=Hydro_Vc Host=Hydro_Vc_mirror                                         |     1 |     2 | kokkos_memory | MB     | 1124 | 1124 |  100 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check    |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check          |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>   |_[kokkos][deep_copy] HIP=Hydro_InvDt Host=Hydro_InvDt_mirror                                   |     1 |     2 | kokkos_memory | MB     |  140 |  140 |  100 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check    |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check          |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>   |_[kokkos][deep_copy] HIP=Hydro_Vs Host=Hydro_Vs_mirror                                         |     1 |     2 | kokkos_memory | MB     |  426 |  426 |  100 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check    |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check          |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence       |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
| |0>>>     |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence             |     1 |     3 | kokkos_memory | MB     |    0 |    0 |    0 |
```

Visualizing Kokkos with Perfetto Trace

- Visualize `perfetto-trace-0.proto` (with sampling enabled)



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Other Executables

- `omnitrace-sample`
  - For sampling with low overhead, use `omnitrace-sample`
  - Use `omnitrace-sample --help` to get relevant options
  - Settings in the OmniTrace config file will be used by `omnitrace-sample`
  - Example invocation to get a flat tracing profile on Host and Device (`-PTHD`), excluding all components (`-E all`) and including only `rocm-smi`, `roctracer`, `rocprofiler` and `roctx` components (`-I ...`)

```
mpirun -np 1 omnitrace-sample -PTHD -E all -I rocm-smi -I roctracer -I rocprofiler -I roctx -- ./Jacobi_hip -g 1 1
```

- `omnitrace-causal`
  - Invokes causal profiling
- `omnitrace-critical-trace`
  - Post-processing tool for critical-trace data output by omnitrace

Current documentation: https://amdresearch.github.io/omnitrace/development.html#executables

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Tips & Tricks

- My Perfetto timeline seems weird how can I check the clock skew?
  - Set `OMNITRACE_VERBOSE=1` or higher for verbose mode and it will print the timestamp skew
- It takes too long to map rocm-smi samples to kernels.
  - Temporarily set OMNITRACE_USE_ROCM_SMI=OFF
- What is the best way to profile multi-process runs?
  - Use OmniTrace's binary rewrite (-o) option to instrument the binary first, run the instrumented binary with mpirun/srun
- If you are doing binary rewrite and you do not get information about kernels, set:
  - HSA_TOOLS_LIB=libomnitrace.so in the env. and set OMNITRACE_USE_ROCTRACER=ON in the cfg file
- My HIP application hangs in different points, what do I do?
  - Try to set HSA_ENABLE_INTERRUPT=0 in the environment, this changes how HIP runtime is notified when GPU kernels complete
- My Perfetto trace is too big, can I decrease it?
  - Yes, with v1.7.3 and later declare OMNITRACE_PERFETTO_ANNOTATIONS to false
- I want to remove the many rows of CPU frequency lines from the Perfetto trace
  - Declare the OMNITRACE_USE_PROCESS_SAMPLING = false

Summary

- OmniTrace is a powerful tool to understand CPU + GPU activity
  - Ideal for an initial look at how an application runs
- Leverages several other tools and combines their data into a comprehensive output file
  - Some tools used are AMD uProf, rocprof, rocm-smi, roctracer, perf, etc.
- Easy to visualize traces in Perfetto
- Includes several features:
  - Dynamic Instrumentation either at Runtime or using Binary Rewrite
  - Statistical Sampling for call-stack info
  - Process sampling, monitoring of system metrics during application run
  - Causal Profiling
  - Critical Path Tracing

Questions?

DISCLAIMERS AND ATTRIBUTIONS