Profiler Tools Overview

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LUMI Performance Tunning Workshop
Jun 11-12th, 2024

AMD
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Background – 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	

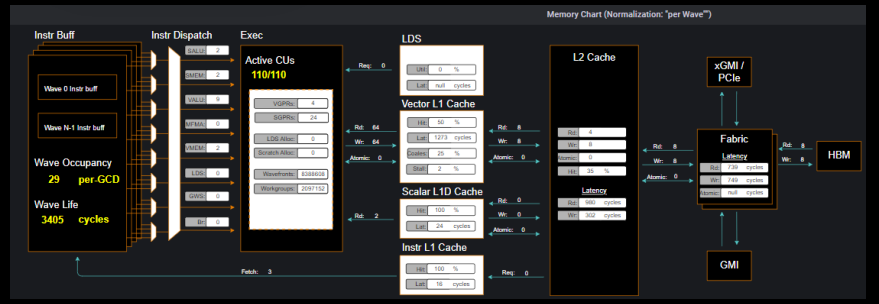
	A	B	C	D	E
1	Name	Calls	TotalDura	AverageN	Percentag
2	hipMemcpyAsync	99	3.22E+10	3.25E+08	44.14872
3	hipEventSynchronize	330	2.42E+10	73394557	33.225
4	hipMemsetAsync	87	7.76E+09	89232696	10.64953
5	hipHostMalloc	9	5.41E+09	6.01E+08	7.415198
6	hipDeviceSynchronize	28	1.32E+09	47006288	1.805515
7	hipHostFree	17	1.05E+09	61534688	1.435014
8	hipMemcpy	41	8.11E+08	19791876	1.113161
9	hipLaunchKernel	1856	58082083	31294	0.079676
10	hipStreamCreate	2	46380834	23190417	0.063625
11	hipMemset	2	18847246	9423623	0.025854
12	hipStreamDestroy	2	15183338	7591669	0.020828
13	hipFree	38	8269713	217624	0.011344
14	hipEventRecord	330	2520035	7636	0.003457
15	hipMalloc	30	1484804	49493	0.002037
16	__hipPopCallConfigura	1856	229159	123	0.000314
17	__hipPushCallConfigur	1856	224177	120	0.000308
18	hipGetLastError	1494	100458	67	0.000138
19	hipEventCreate	330	76675	232	0.000105
20	hipEventDestroy	330	64671	195	8.87E-05
21	hipGetDevicePropertie	47	51808	1102	7.11E-05
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

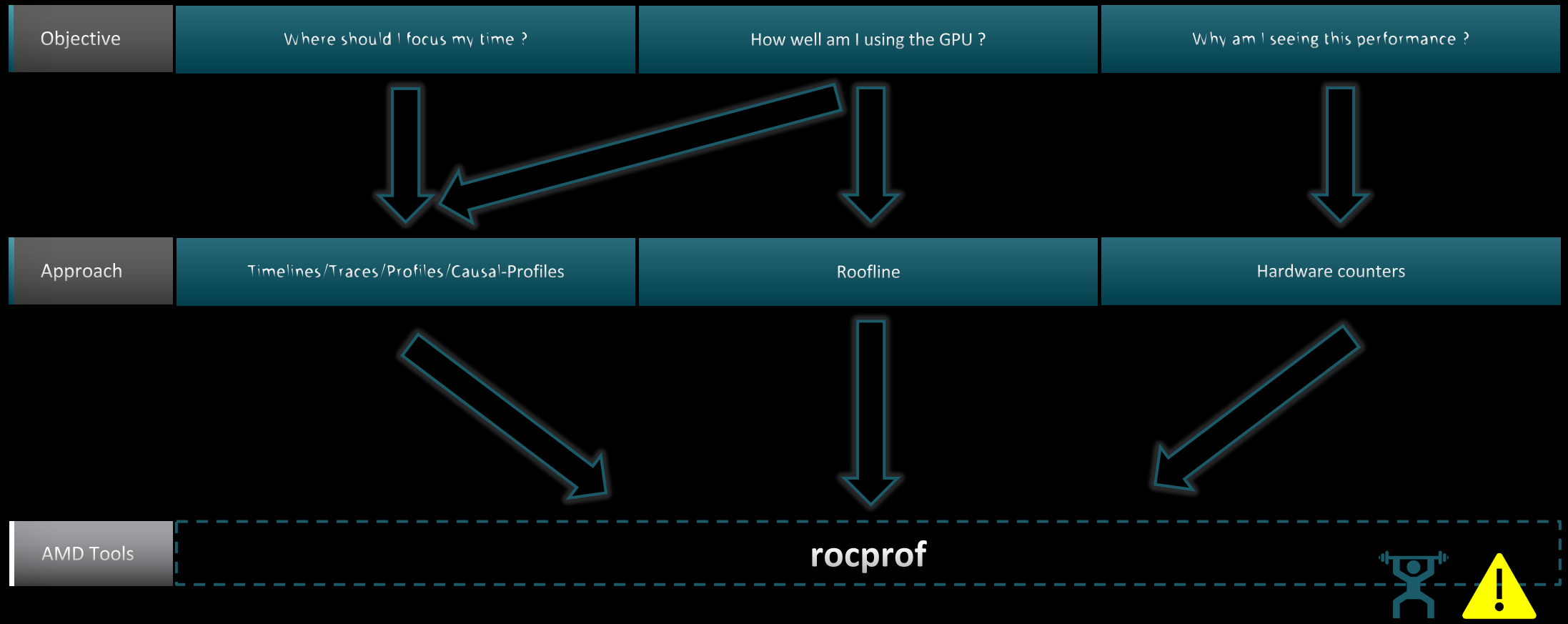
Trace collection	Comprehensive trace collection				
	CPU	GPU			
Supports	CPU copy	HIP API	HSA API	GPU Kernels	
	OpenMP®	MPI	Kokkos	p-threads	multi-GPU
Visualisation	Traces visualized with Perfetto				

Omniperf

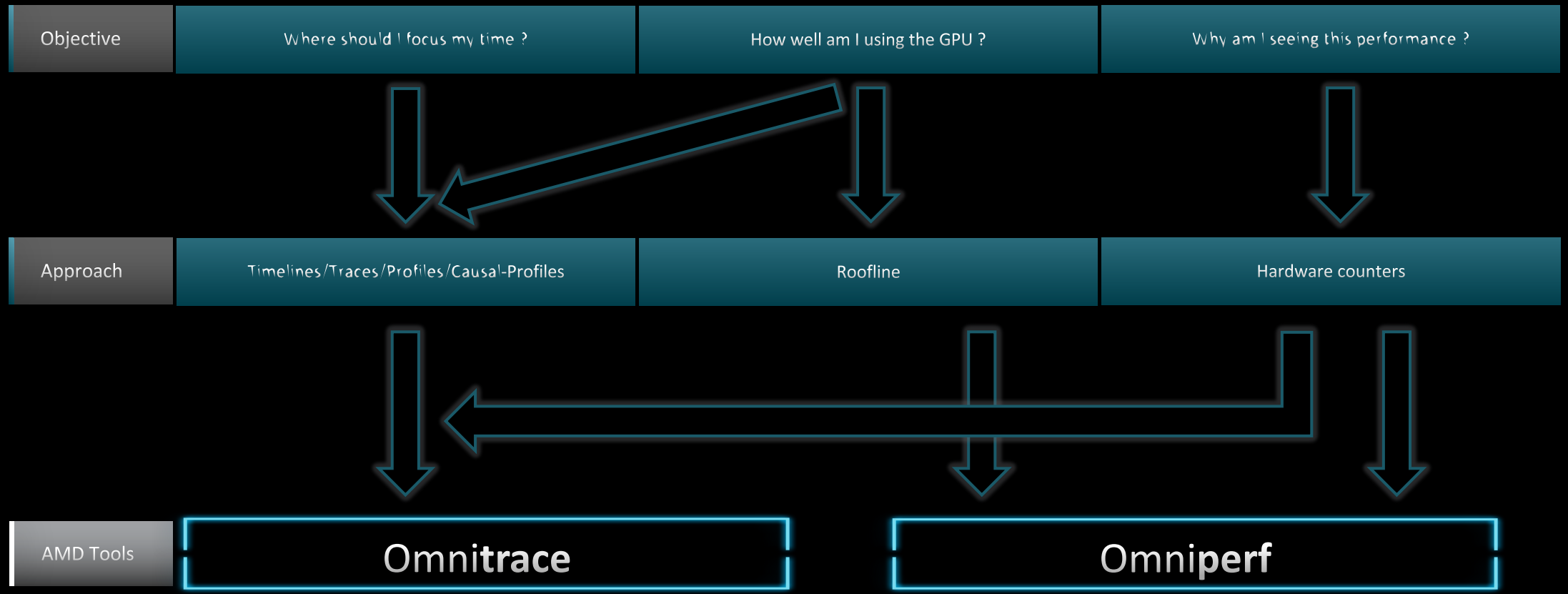
Performance Analysis	Automated collection of hardware counters			
	Analysis	Visualization		
Supports	Speed of Light	Memory chart	Rooflines	Kernel comparison
Visualisation	With Grafana or standalone GUI			



Background – AMD Profilers



Background – AMD Profilers



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/)
- There are ROCProfiler V1 and V2 (roctracer and rocprofiler into single library, same API)
- A new rocprofiler-sdk is going to be released soon, the repository is public: https://github.com/ROCm/rocprofiler-sdk development is **still** going on, no version is released yet

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.

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 to see 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:

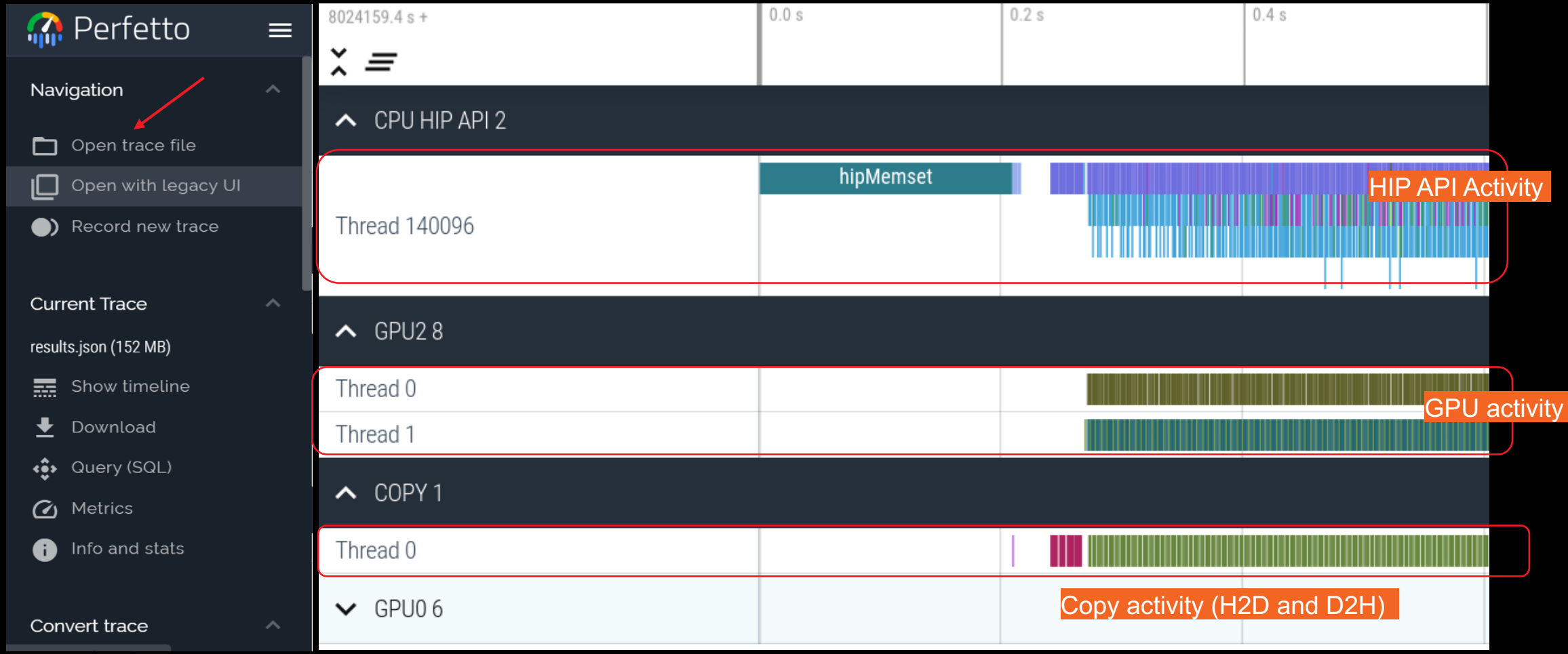
	A	B	C	D	E
1	Name	Calls	TotalDurationNs	AverageNs	Percentage
2	JacobiIterationKernel	1000	556699359	556699	43.2917538952704
3	NormKernel1	1001	430797387	430367	33.5009806553946
4	LocalLaplacianKernel	1000	280014065	280014	21.7753079704808
5	HaloLaplacianKernel	1000	14635177	14635	1.1381052818811
6	NormKernel2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

rocprof + Perfetto: Collecting and Visualizing Application Traces

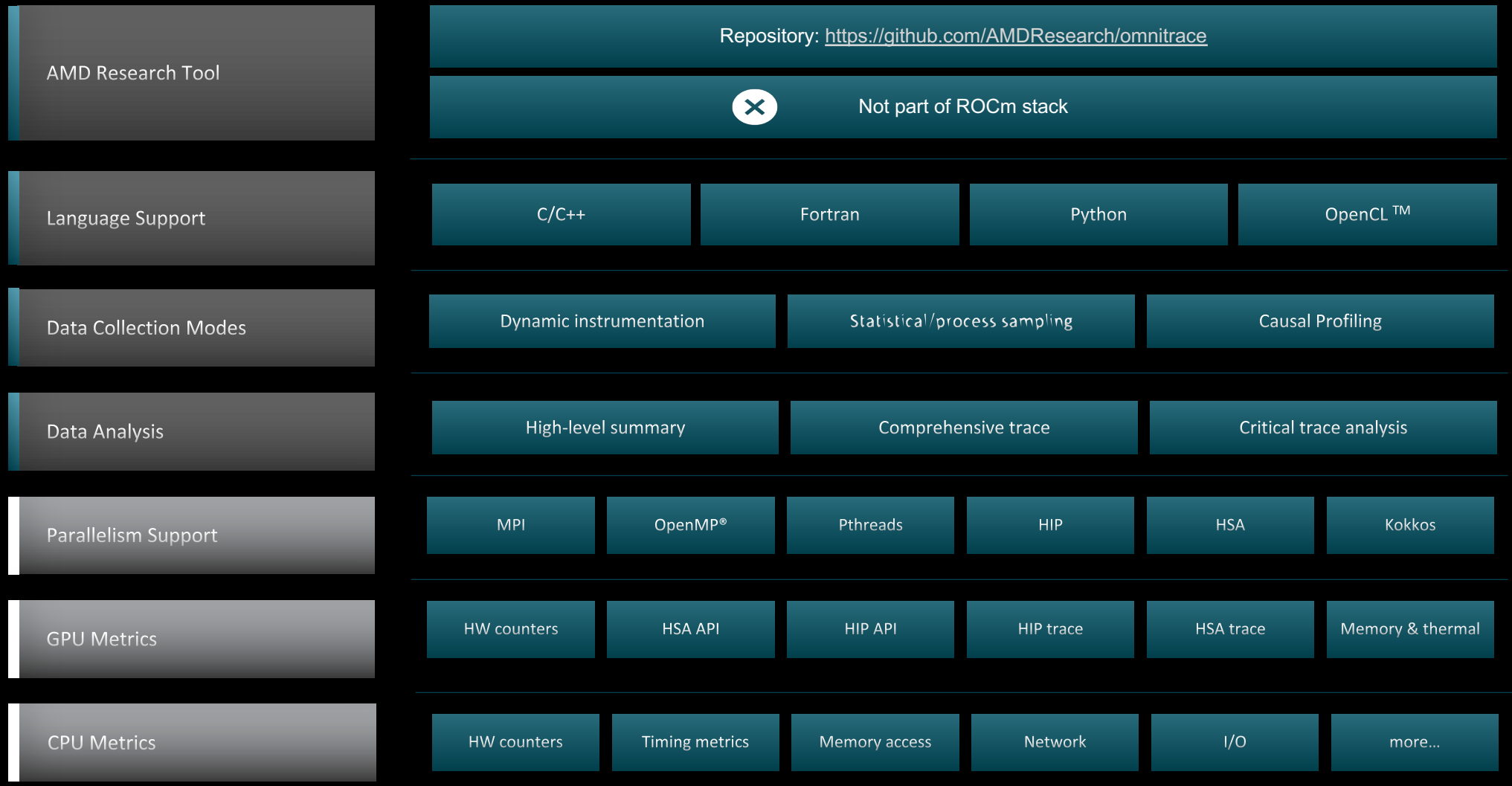
- rocprof can collect traces

  ```
  $ /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/)

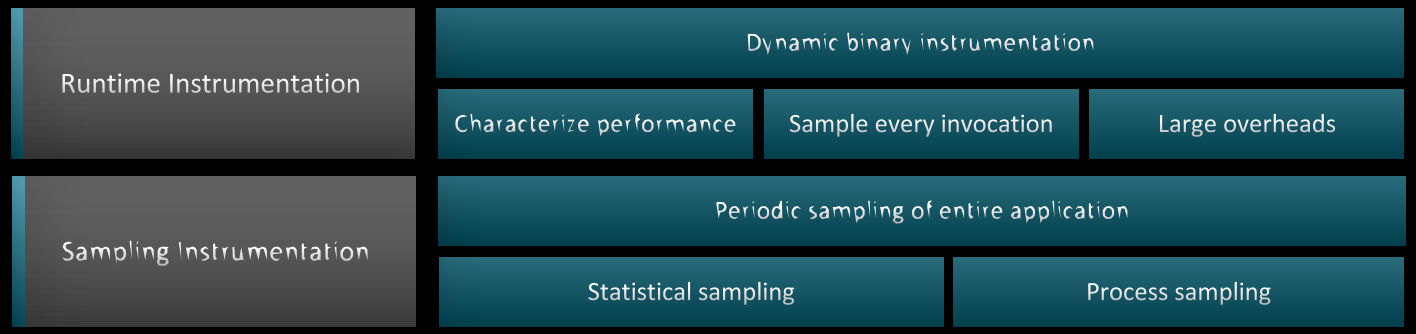


Omnitrace: Application Profiling, Tracing, and Analysis



Refer to current documentation for recent updates

Omnitrace instrumentation Modes



Basic command-line syntax:

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

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

```
$ omnitrace -h
```

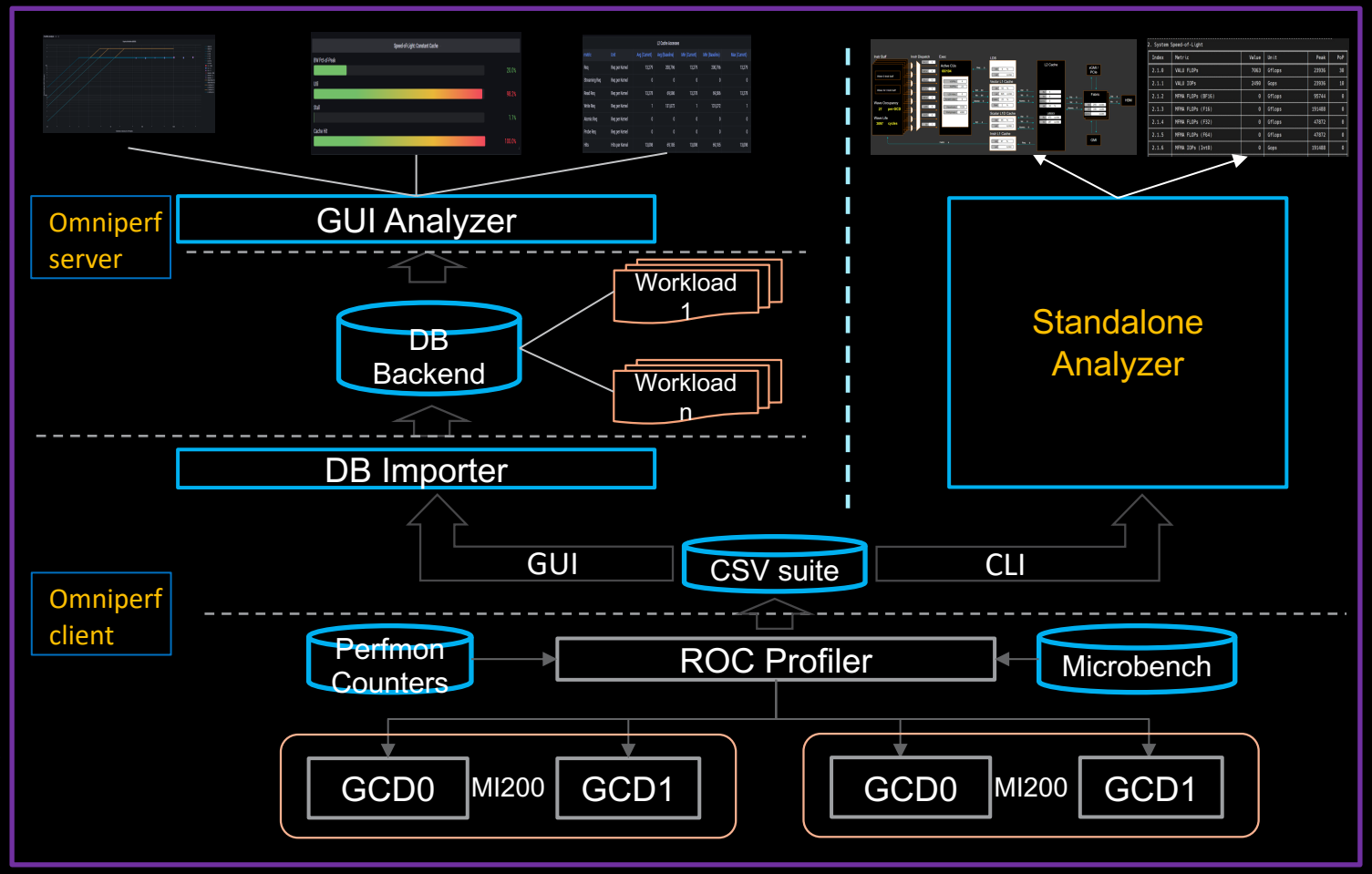
Can also execute on systems using a job scheduler. For example, with SLURM, an interactive session can be used as:

```
$ 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/

Omniperf: Automated Collection of Hardware Counters and Analysis

AMD Research Tool	Repository: https://github.com/AMDResearch/omniperf			
	✗ Not part of ROCm stack	Built on top of ROC-profiler		
Integrated Performance Analyzer for AMD GPUs	Speed-of-Light	Roofline	Memory chart	Baseline comparison
	Sub-system performance analysis			
	LDS	vL1D	L2 Cache	HBM
	Shader Compute	Wavefront	Instruction mix	Latencies
INSTINCT™ Support	MI200	MI100		
User Interfaces	Grafana™ GUI	Standalone GUI	Command Line (CLI)	



Refer to current documentation for recent updates

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 rocprof_wrapper.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

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

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