

AMD ROCm GPU profiling in Trace Compass

Arnaud Fiorini with Pr. Michel Dagenais May 8th, 2020

Polytechnique Montreal

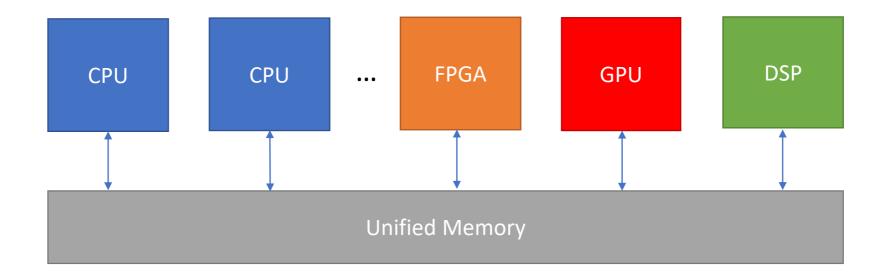
DORSAL Laboratory

- I. Introduction
 - 1. GPU Development
 - 2. Optimization Problems
- II. Tracing and profiling of CPU-GPU systems
 - 1. ROC Platform
 - 2. Tracing GPUs
 - 3. Profiling GPUs

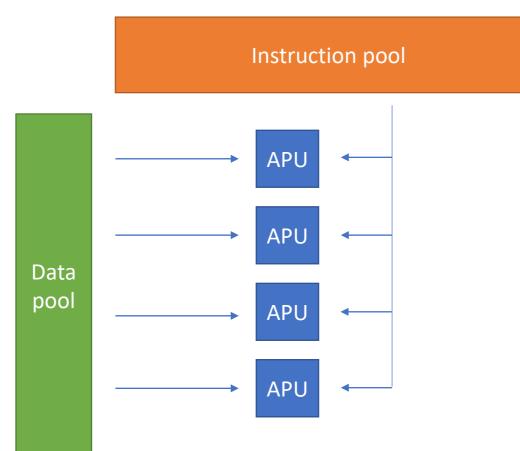
- A few definitions :
 - Kernel : A small piece of code executed on the device.

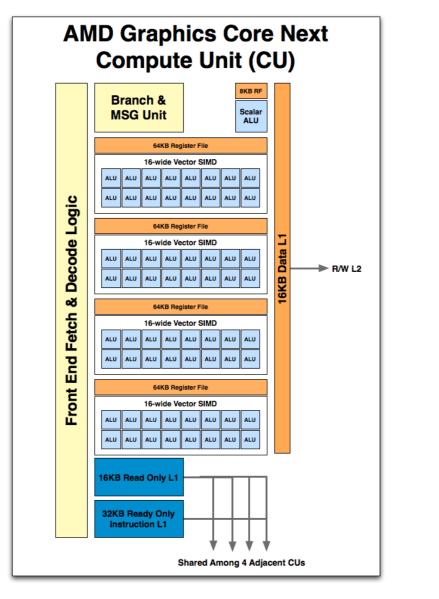
```
__kernel void saxpy(__global float *src, __global float *dst, float factor)
{
    long i = get_global_id(0);
    dst[i] += src[i] * factor;
}
```

- A few definitions :
 - Kernel : A small piece of code executed on the device.
 - Heterogeneous system : system mixing multiple types of processors



• SIMD Architecture :







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Optimization Problems - Introduction

- Communication Overhead :
 - Memory synchronisation
 - Interprocessor Communication
- Scheduling and load balancing :
 - Benchmarking
 - Load characteristics of kernels
- Shared Cache :
 - Cache misses, thrashing

Optimization Problems - Introduction

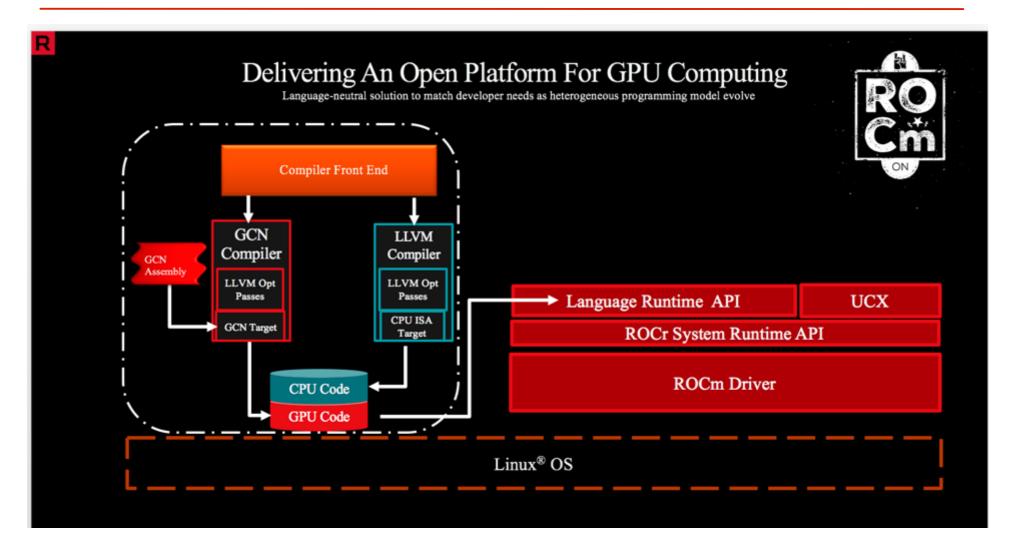
- Communication Overhead :
 - Memory synchronisation _____ Tracing
 - Interprocessor Communication
- Scheduling and load balancing :
 - Benchmarking
 - Load characteristics of kernels

Profiling (Performance Counters)

- Shared Cache :
 - Cache misses, thrashing

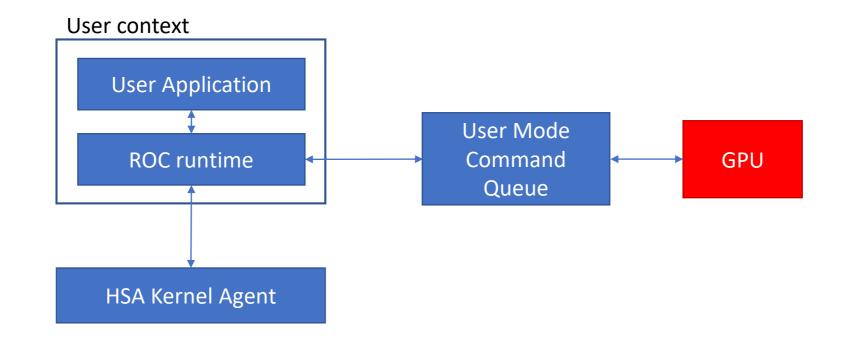
Agenda

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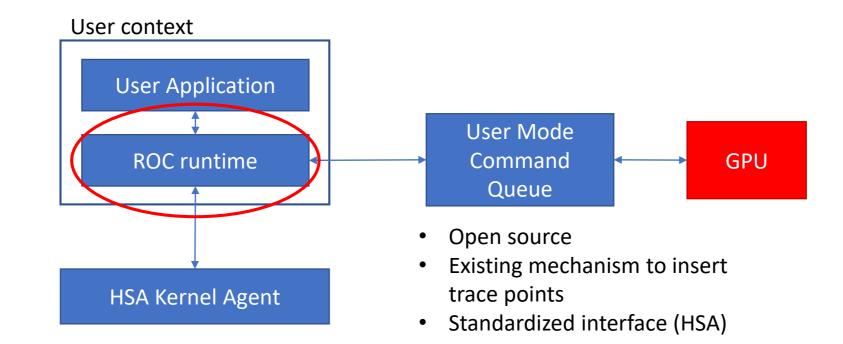


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ROCm functioning summarized :

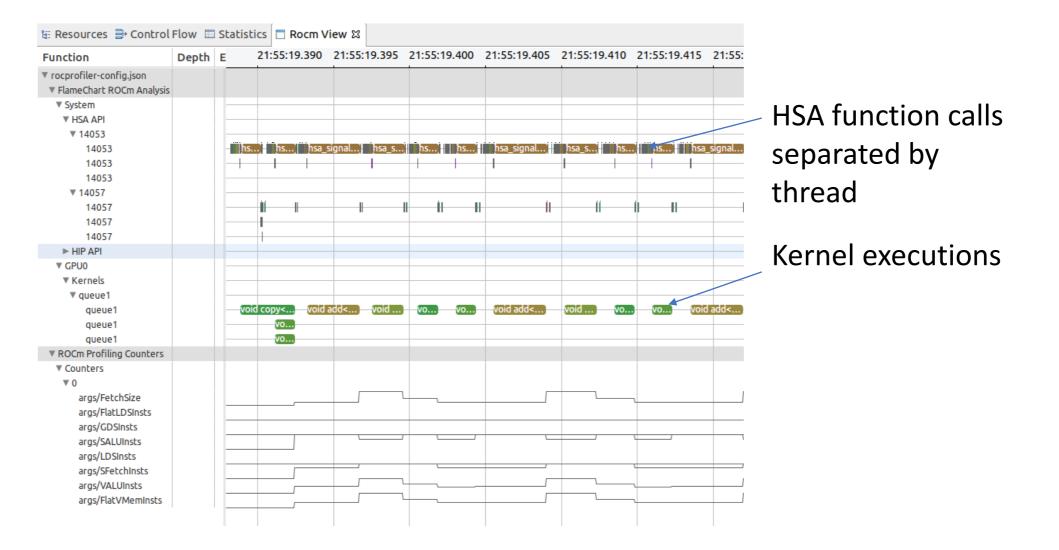


ROCm functioning summarized :

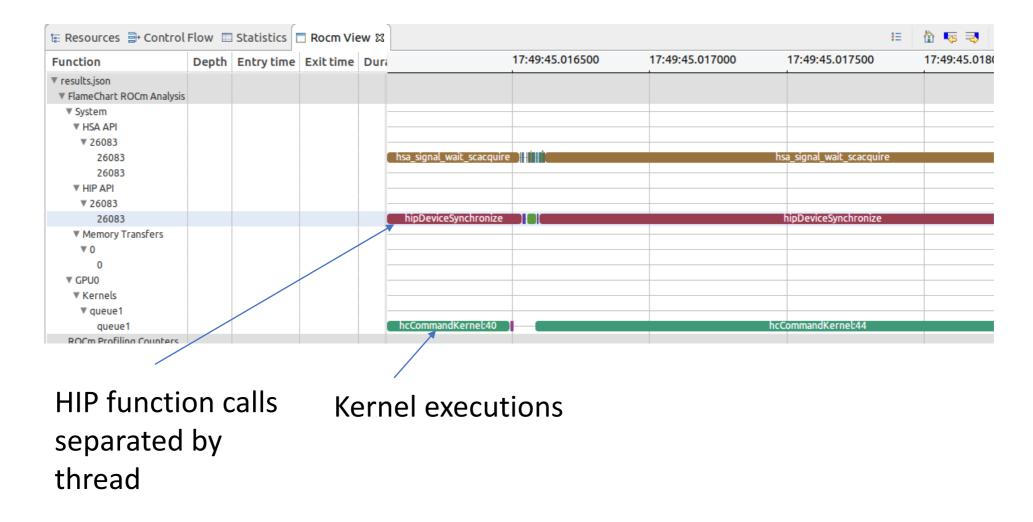


- This work has already been done by AMD and is open source : <u>https://github.com/ROCm-Developer-Tools/rocprofiler</u> <u>https://github.com/ROCm-Developer-Tools/roctracer</u>
- AMD has released a few other libraries and tools thanks to their Radeon Open Compute initiative.

TraceCompass ROCm plugin



TraceCompass ROCm plugin



TraceCompass ROCm plugin running on Theia front-end

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| | Workspace |
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| | .bash_history |
| | .bash_logout |
| | ■ .bashrc |
| | • .dmrc |
| | ♦ .fehbg |
| | ♦ .gitconfig |
| | ✿ .ICEauthority |
| | .node_repl_history |
| | notes.txt.swp |
| | profile |
| | .python_history |
| | .repogitconfig.json |
| | .sudo_as_admin_successful |
| | viminfo |
| | K .vimrc |
| | .wget-hsts |
| _ | X .Xauthority |
| | X .xinitrc |
| _ | X .Xresources |
| | X .xsession-errors |
| | .xsession-errors.old |
| | ♦ .yarnrc |
| | # examples.desktop |
| | log |
| | presentation_progress_meeting.odp |
| | I rocprofiler-config.csv |
| | ✓ rocprofiler-config.db |
| | b rocprofiler-config.hsa_stats.csv |
| _ | <pre>support = rocprofiler-config.json</pre> |
| | L rocprofiler-config.stats.csv |
| | rocprofiler-config.txt |
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Analyzing this tracing data further, future work includes :

- Critical path analysis of CPU-GPU execution
- Determining whether the program performance is limited by the GPU or the CPU
- Extracting statistics to use in profiling analysis

TraceCompass ROCm plugin

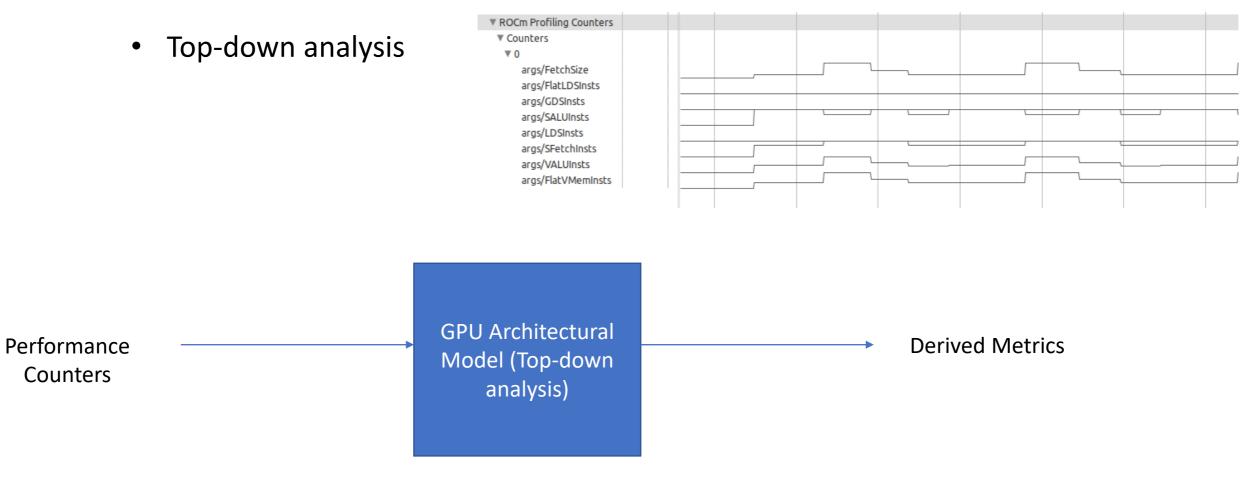
| Function | Depth | E | 21:55:19.390 | 21:55:19.395 | 21:55:19.400 | 21:55:19.405 | 21:55:19.410 | 21:55:19.415 | 21:55: | |
|----------------------------|-------|-------|---|---------------|--------------|--------------|--------------|-----------------|----------|-------------|
| rocprofiler-config.json | | | | | | | | | | |
| ▼ FlameChart ROCm Analysis | | | | | | | | | | |
| ▼ System | | | | | | | | | | |
| ▼ HSA API | | | | | | | | | | |
| ▼ 14053 | | | | | | | | | | |
| 14053 | | – hs. | hshsa_s | signal] hsa_s | hs hs | hsa_signal | hsa_s hs | . hs hsa | _signal] | |
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| 14057 | | | | | | | | | | |
| ► HIP API | | | | | | | | | | |
| ▼ GPU0 | | | | | | | | | | |
| ▼ Kernels | | | | | | | | | | |
| ▼ queue1 | | | | | | | | | | |
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| queue1 | | | vo | | | | | | | |
| queue1 | | | vo | | | | | | | Performance |
| ROCm Profiling Counters | | | | | | | | | | Performance |
| ▼ Counters | | | | | | | | | | |
| ▼ 0 | | | | | | | | | | counters |
| args/FetchSize | | | | | 4 | | | <i>٦</i> ــــــ | | Counters |
| args/FlatLDSInsts | | | | | | | | | | |
| args/GDSInsts | | | | | | | | | | |
| args/SALUInsts | | | | | | | | <u> </u> | 1 | |
| args/LDSInsts | | | | | | | | | | |
| args/SFetchInsts | | | | | | | | 1 | <u> </u> | |
| args/VALUInsts | | | | | · | + | | · | <u> </u> | |
| args/FlatVMemInsts | | | | | 4 | | | \ | | |

- π 2 Performance [GFLOPS] 1 O₂(compute-bound) O₁(memory-bound) 2 1/2 1/4 1/4 1/2 32 64 128 8 16 2 Operational Intensity [FLOPS/byte] β : peak bandwidth
- Roofline model

- I : arithmetic intensity
- π : peak performance

- π 2 Performance [GFLOPS] 1 Х O₂(compute-bound) O₁(memory-bound) хх \mathfrak{C} X 1/2 1/4 1/4 1/2 32 64 128 8 16 2 Operational Intensity [FLOPS/byte]
- **Roofline model** \bullet

- β : peak bandwidth
- I : arithmetic intensity
- π : peak performance



| r | Top-down Grouping: Function / | - | ROCm Profiling Counters Counters 0 args/FetchSize args/FlatLDSInsts args/GDSInsts | | | | | | | |
|-------------|------------------------------------|-------------------------|---|---------------------------------|--------------------|---------------|-------------------------|----------|------|----|
| - | Grouping. Tunction / | | | | | Back-End B | | | | |
| | Function / Call Stack | Instructions Retired | CPI Rate | Front-End [»] Bound | Bad Speculation | Memory Bound» | Bound « Core Bound » | Retiring | | |
| | price_out_impl | 62,556,093,834 | 1.261 | 2.2% | 7.4% | 64.2% | 8.4% | 17.8% | | Í. |
| | refresh_potential | 17,836,026,754 | 3.589 | 3.0% | 8.1% | 73.2% | 9.6% | 6.1% | | |
| | primal_bea_mpp | 38,108,057,162 | 1.393 | 5.6% | 24.3% | 34.4% | 21.0% | 14.7% | | |
| - | update_tree | 4,092,006,138 | 3.373 | 7.2% | 11.5% | 62.3% | 11.8% | 7.2% | | |
| - | sort_basket | 12,246,018,369 | 1.037 | 20.7% | 50.4% | 3.8% | 4.6% | 20.6% | | |
| Performance | primal_iminus | 5,324,007,986 | 2.148 | 7.1% | 6.7% | 55.0% | 20.5% | 10.8% | rics | |
| Counters | primal_net_simple: | 266,000,399 | 2.466 | 17.4% | 43.4% | 13.1% | 13.1% | 13.0% | | |
| - | | | ć | anaiysis) | | | | | | |

Thank you for listening !

Questions ?

References

- <u>https://github.com/RadeonOpenCompute/ROCm</u>
- <u>https://rocm-documentation.readthedocs.io/en/latest/</u>
- http://www.hsafoundation.com/
- HSA Runtime Programmer's Reference Manual, Version 1.2
- HSA Programmer's Reference Manual, Version 1.2
- HSA Platform System Architecture Specification, Version 1.2
- <u>https://github.com/ucb-bar/opencl-kernels/blob/master/saxpy/kernel.cl</u>
- <u>https://medium.com/@smallfishbigsea/basic-concepts-in-gpu-computing-3388710e9239</u>
- <u>https://www.techpowerup.com/gpu-specs/docs/amd-gcn1-architecture.pdf</u>
- <u>https://software.intel.com/content/www/us/en/develop/docu</u> <u>mentation/vtune-cookbook/top/methodologies/top-down-</u> <u>microarchitecture-analysis-method.html</u>