Systematic Performance Benchmarking of Emerging HPC Processors for Hemocell

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Main goal

Creating a comprehensive benchmarking and performance analysis framework tailored to Hemocell. And use it to benchmark and analyse the performance and energy consumption of Hemocell on a selection of new-generation computing architectures.

Benchmarking and Performance Analysis Framework

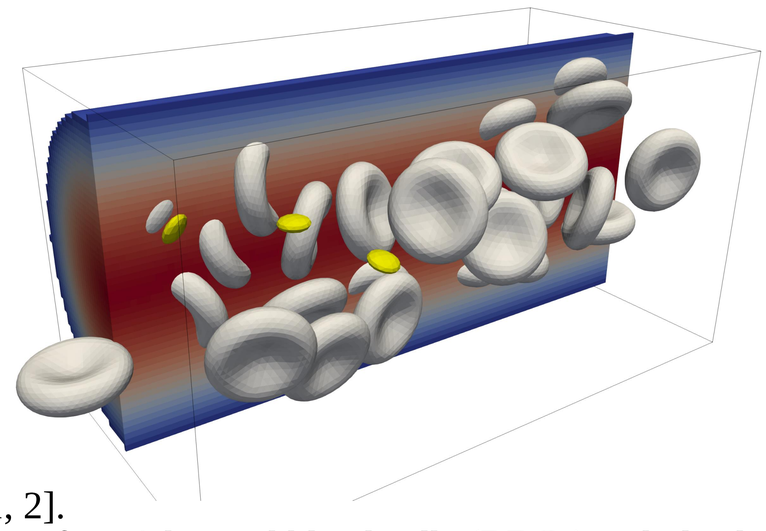
1: Setup
Choose the tools, benchmarks and platforms

2: Benchmarking
Measure Hemocell performance and platform peak performance

3: Performance Overview
Look at a performance overview to gain insights into the performance.

4: Detailed Performance Analysis
Use hardware events to explain the behavior observed in step 3.

Use-Case



Hemocell, a coupled biomedical code for blood flow simulation [1, 2].
Blood is modelled as a set of particles, red blood cells (RBCs) and platelets, in a fluid, blood plasma. The particles and fluid are modelled separately and coupled to create the full blood flow simulation.

1 & 2. Setup & Benchmarking

Dual 65-core
Intel Sapphire Rapids HBM 9480
128 GB Memory

- GCC 13.2.0/Open MPI 4.1.5
- Stream: 1400 GB/s
- HPL: 5.45 TFLOPs

Single 80-core
Ampere Altra Q8030
265 GB Memory

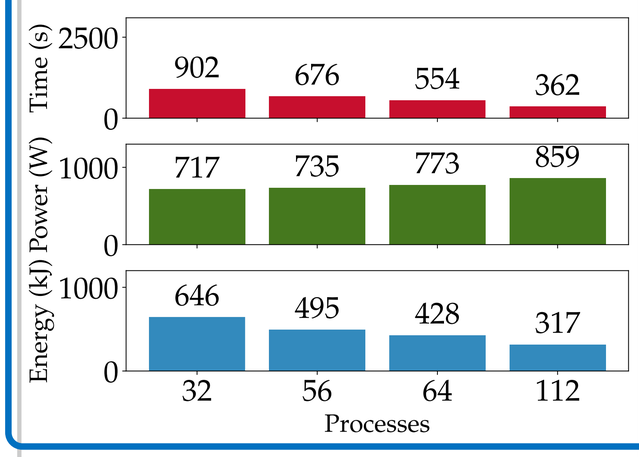
- GCC 8.5.0/Open MPI 4.1.5
- Stream: 175 GB/s
- HPL: 1.18 TFLOPs

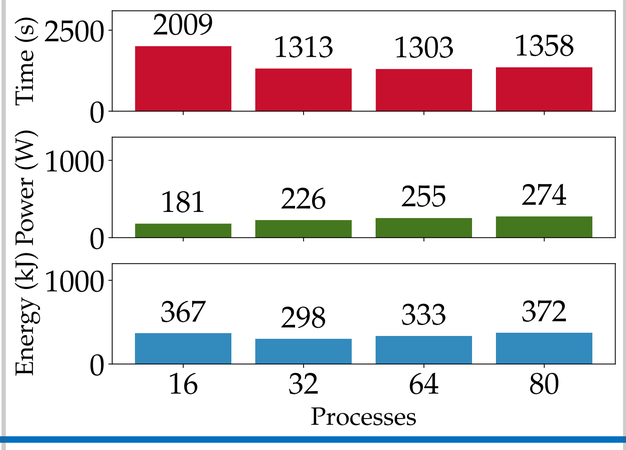
Dual 96-core
AMD Genoa 9654
384 GB Memory

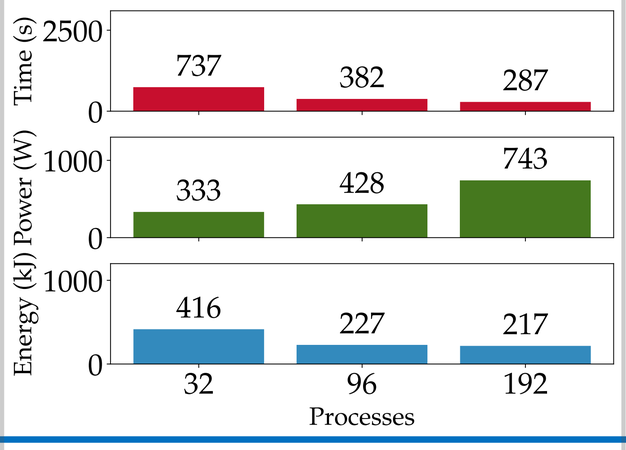
- GCC 13.2.0/Open MPI 4.1.5
- Stream: 700 GB/s
- HPL: - TFLOPs

- High Bandwidth Memory (HBM) provides higher bandwidth.
- Ampere Altra is an ARM processor designed to be power efficient.

3. Performance Overview







- AMD Genoa is the fastest and uses the least amount of energy.
- Ampere lowest power requirement. But it does not scale above 32 processes.
- Highest memory bandwidth does not mean best performance

4. Detailed Analysis

	Processes	
	56	112
Runtime [s]	677	363
Instructions $\times 10^{12}$	215	253
Cycles $\times 10^{12}$	1.54	0.86
CPI	0.40	0.38
Data Volume [TB]	805	924
Bandwidth [GB/s]	1189	2544

	Processes	
	64	80
Runtime [s]	1306	1360
Instructions $\times 10^{12}$	208	179
Cycles $\times 10^{12}$	3.59	3.68
CPI	1.11	1.64
Data Volume [TB]	631	538
Bandwidth [GB/s]	483	395

	Processes	
	96	192
Runtime [s]	383	288
Instructions $\times 10^{12}$	188	309
Cycles $\times 10^{12}$	0.79	0.69
CPI	0.40	0.43
Data Volume [TB]	760	1256
Bandwidth [GB/s]	1984	4360

- Hemocell is unable to use all the available memory bandwidth.
- A higher memory bandwidth does not guarantee improved performance. However, enabling HBM improves Intel SPR performance by 1.3X.
- CPI alone is not a useful performance indicator.

Take Home Message

Detailed performance analysis is difficult. Simple metrics such as runtime and energy consumption do not provide the necessary insight. But for more detailed results the tool availability varies between platforms and architectures, access to hardware events is can be limited, and performance metrics are difficult to interpret. A systematic approach to benchmarking and performance analysis can help provide structure to this non-trivial task.

More info ?

Get in touch!

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References

[1]G. Zavodszky, B. van Rooij, V. Azizi, S. Alowayyed, and A. Hoekstra, "Hemocell: a high-performance microscopic cellular library," Procedia Computer Science, vol. 108, pp. 159–165, Jan. 2017, doi: 10.1016/j.procs.2017.05.084.
[2]G. Závodszky, B. van Rooij, V. Azizi, and A. Hoekstra, "Cellular Level In-silico Modeling of Blood Rheology with An Improved Material Model for Red Blood Cells," Front Physiol, vol. 8, Aug. 2017, doi: 10.3389/fphys.2017.00563.