



POP3: Performance Optimisation and Productivity Center of Excellence

(POP CoE)

HORIZON-EUROHPC-JU-2023-COE



EuroHPC
Joint Undertaking

Grant Agreement No 101143931

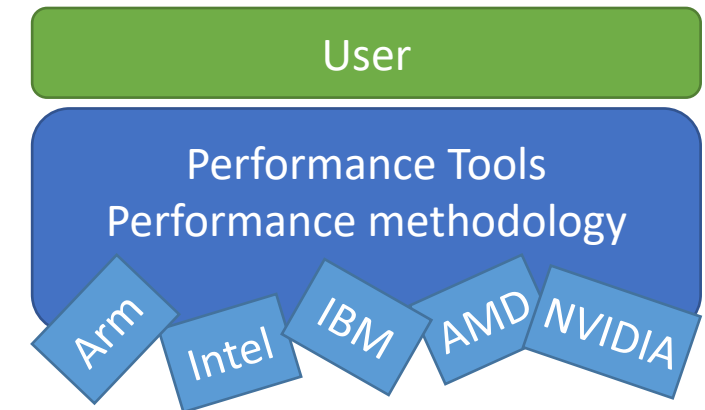
1 January 2024– 31 December 2026

- A **Centre of Excellence**
 - On **Performance Optimisation and Productivity**
 - Promoting **best practices in parallel programming**
- Providing **FREE Services**
 - Precise understanding of application and system behaviour
 - Suggestion/support on how to refactor code in the most productive way
- **Horizontal**
 - Transversal across application areas, platforms, scales
- **For (EuroHPC) academic AND industrial codes and users !**

Context and history



- **POP-CoE** started in 2015
- Objectives:
 - To offer performance analysis services to European HPC users.
 - To develop a common methodology for performance analysis
- **POP1** ran from October 2015 to March 2018
- **POP2** ran from December 2018 to June 2022
- **POP3** runs from January 2023 to December 2026



Partners



• Who?

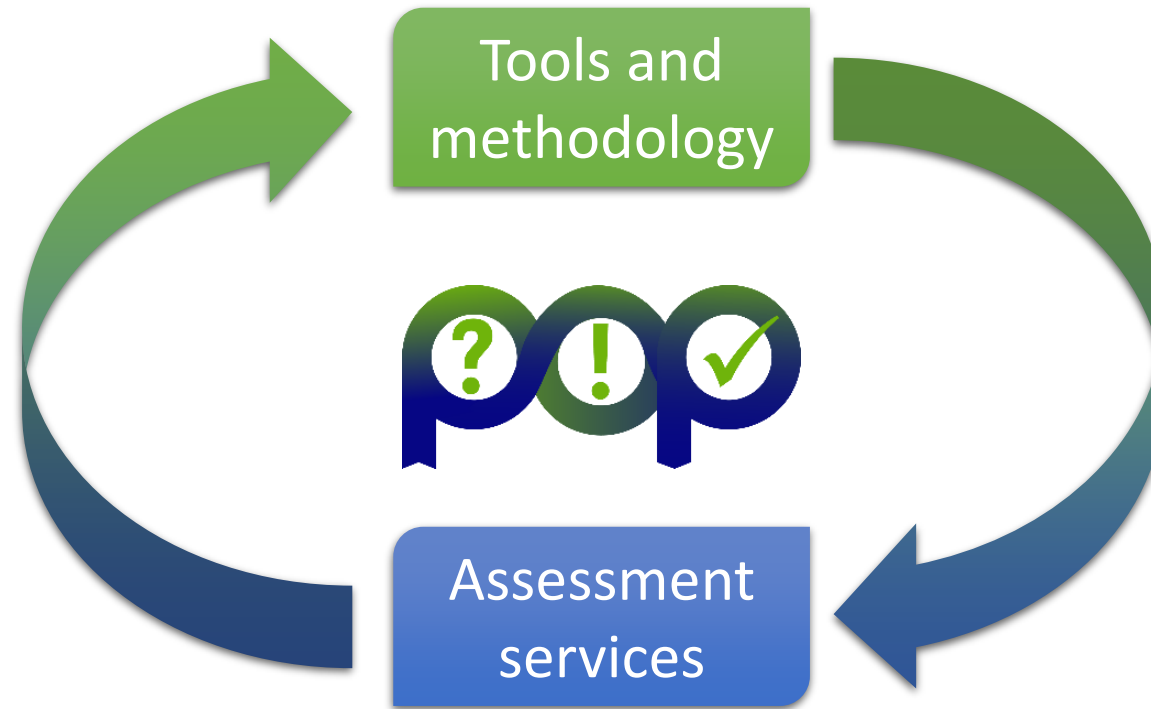
- BSC, ES (coordinator)
- HLRS, DE
- INESC-ID, PT
- IT4I, CZ
- JSC, DE
- RWTH Aachen, IT Center, DE
- TERATEC, FR
- UVSQ, FR



A team with

- Excellence in performance tools and tuning
- Excellence in programming models and practices
- Research and development background AND proven commitment in application to real academic and industrial use cases

Objectives





- **Parallel Application Performance Assessment**

- Primary service
- Initial analysis measuring a [range of performance metrics](#) to assess quality of performance and identify the issues affecting performance (at customer site)
- If needed, undertakes further performance evaluations to identify the root causes of the issues found and qualify and quantify approaches to address them (recommendations)

- **Second Level Services**

- Second level services may follow after conclusion of an initial performance assessment:
 - **Proof-of-concept**: explore the potential benefit of proposed optimisations by applying them to selected regions of the applications
 - **Correctness-check**: evaluate the correctness of hybrid MPI + OpenMP applications
 - **Energy-efficiency study**: investigate improvements of energy consumption or efficiency
 - **Advisory study**: ongoing consultancy for customers that choose to implement proposed optimisations on their own

- **Note: Effort shared between our experts and customer!**

- **Code developers**

- Assessment of detailed actual behaviour
- Suggestion of most productive directions to refactor code

- **Users**

- Assessment of achieved performance in specific production conditions
- Possible improvements modifying environment setup
- Evidence to interact with code provider

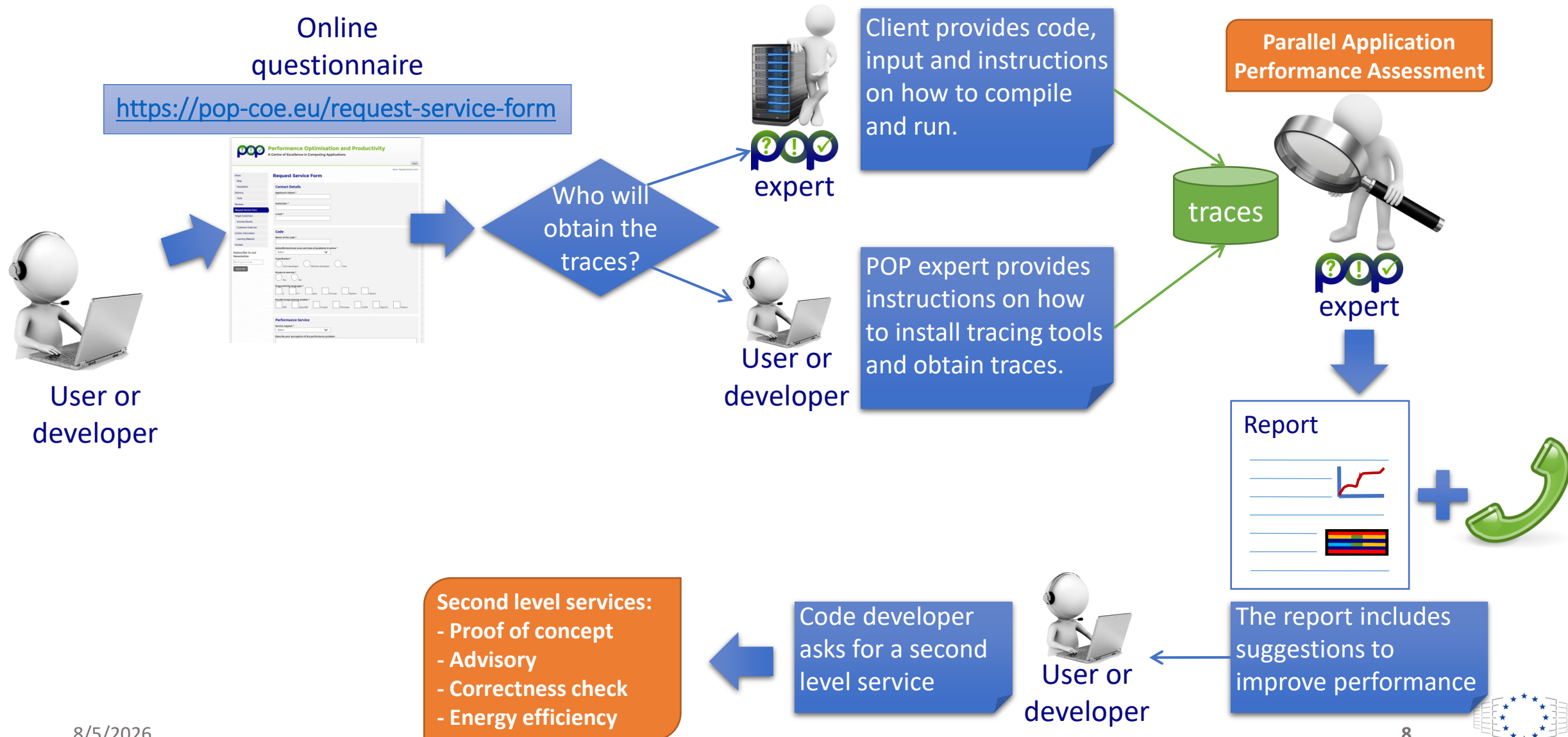
- **Infrastructure operators**

- Assessment of achieved performance in production conditions
- Possible improvements from modifying environment setup
- Information for time computer time allocation processes
- Training of support staff

- **Vendors**

- Benchmarking
- Customer support
- System dimensioning/design

POP3 services



Success story: Tools scale up to 112k cores



Can the tools operate at this scale?

All the tools were able to run and obtain the POP efficiency metrics

1K nodes of Marenstrum5-GPP

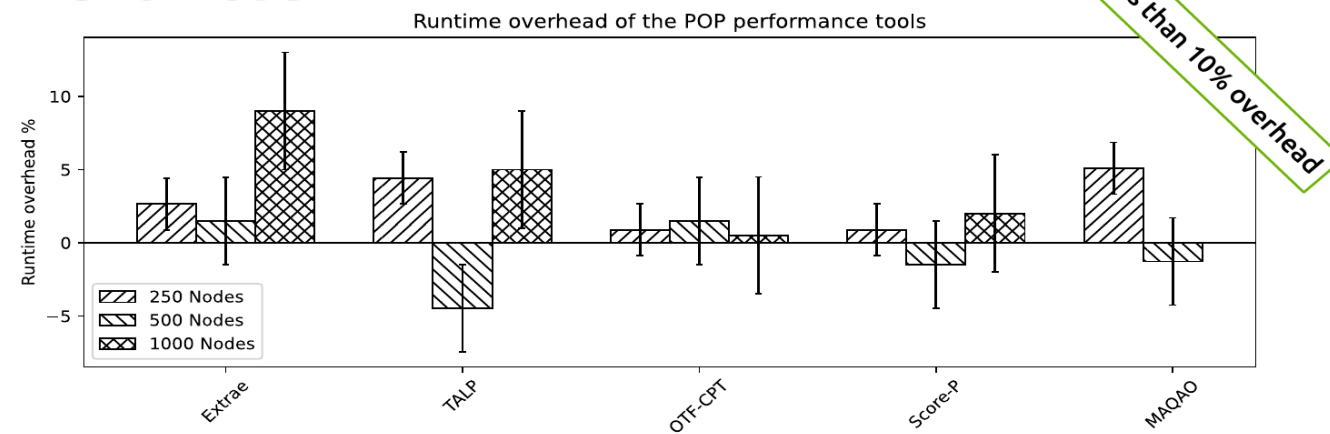
Production run of Vlasiator from Plasma-PEPSC CoE

	Parallel Efficiency			Load Balance			Communication Efficiency		
	250 Nodes	500 Nodes	1000 Nodes	250 Nodes	500 Nodes	1000 Nodes	250 Nodes	500 Nodes	1000 Nodes
OTF-CPT	0.17	0.13	0.10	0.31	0.28	0.22	0.53	0.47	0.45
Extræe	0.15	0.12	0.08	0.31	0.29	0.27	0.53	0.48	0.35
TALP	0.16	0.12	0.10	0.33	0.3	0.26	0.89	0.86	0.86
Score-P	0.17	0.13	0.10	0.31	0.26	0.22	0.56	0.49	0.42
MAQAO	0.64	0.15	0.37	0.89	0.19	0.60	0.72	0.79	0.61

How is the overhead of the tools?

The overhead was below 10% in all cases, and feedback was gathered to improve the tools

Overhead

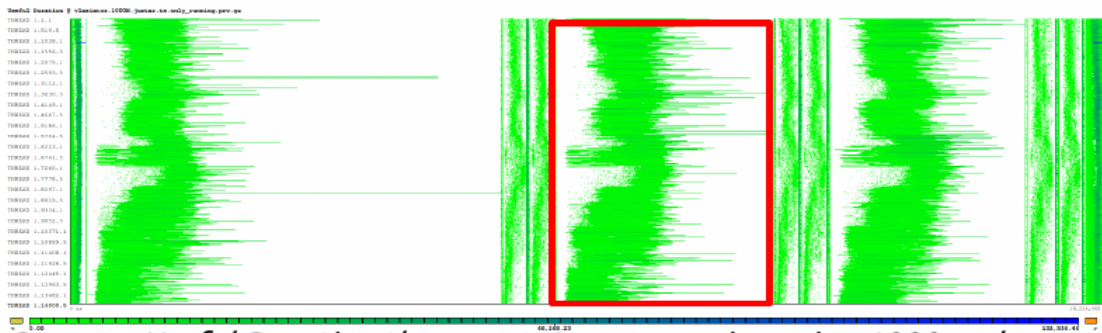


Success story: Tools scale up to 112k cores



Can we obtain detailed insights from the gathered data?

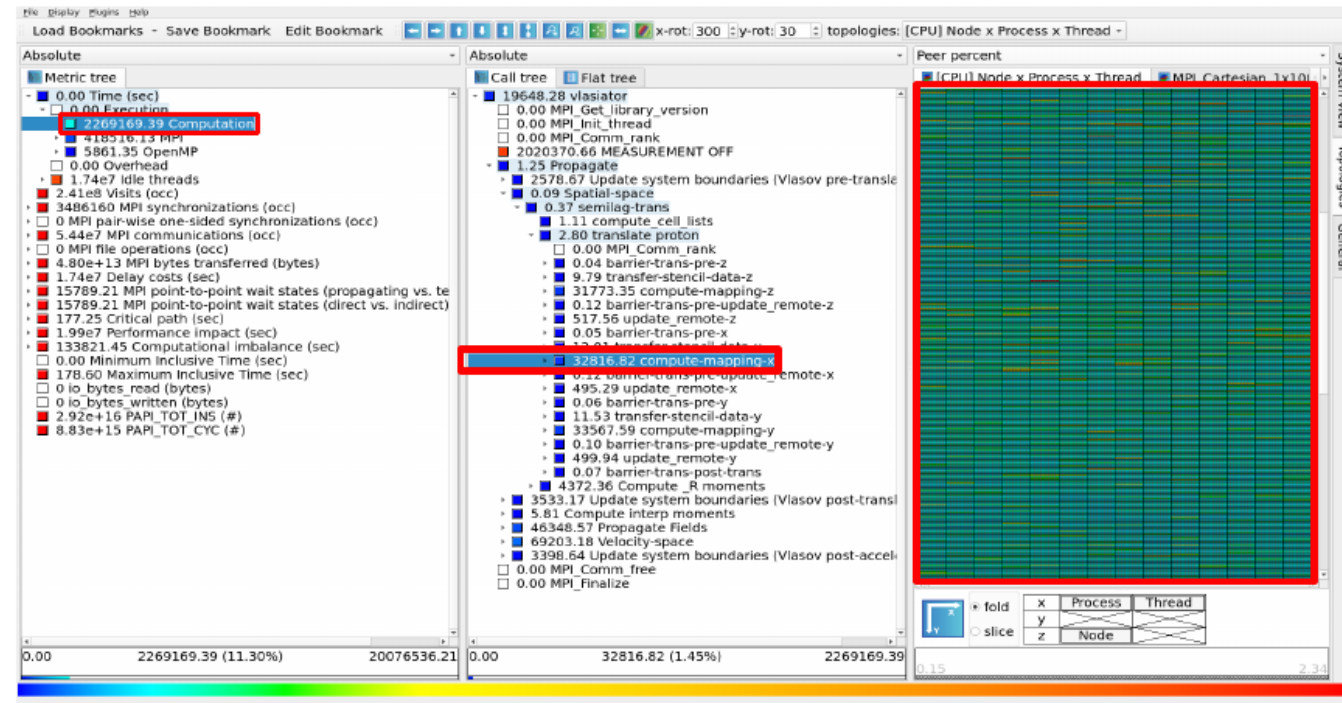
The “trace-based” tools were able to analyze the traces and provide insightful information



Paraver: Useful Duration the Spatial Space region using 1000 nodes

Can we also achieve large scale analysis with GPUs?

We have conducted a similar analysis using GPUs, data is being analyzed. Soon more details!



Cube: Scalasca generated profile of the 1000 node execution

Success story: 3.5x speedup in Alya+ISAT lib

Performance assessment of an EXCELLERAT use case running Alya and ISAT library to solve the chemical reactions.

Conclusions from performance analysis :

- **Load Imbalance:** is due to frequency variations
- **Frequency:** low values inside istab routine from ISAT lib.
→ Frequency issues are due to an intensive use of cpu_time routine by ISAT library

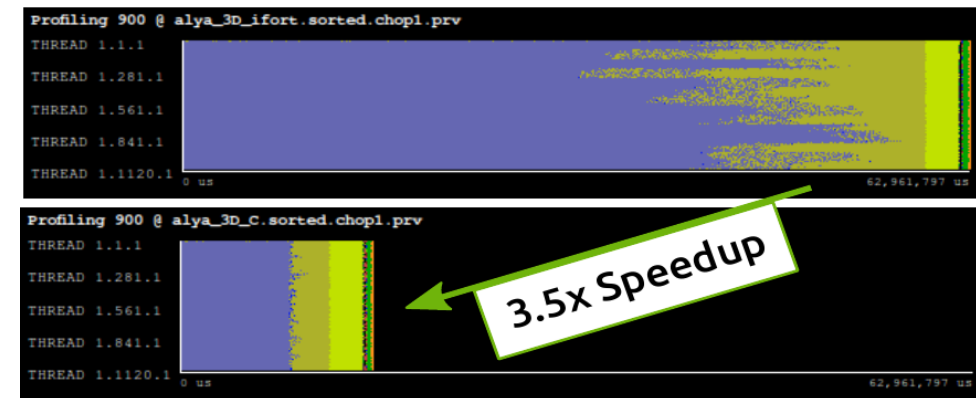
Proof-of-concept conducted to avoid the use of the cpu_time implementation of the Fortran runtime.

Achieved a speedup of the overall execution of 3.5x.

POP efficiency metrics show that the main issues were solved

3D CASE			
Number of processes	1120	4480	8960
Global efficiency	80.73%	79.80%	76.87%
Parallel efficiency	80.73%	80.09%	76.02%
Load balance	81.21%	81.04%	81.47%
Communication eff.	99.41%	98.83%	93.31%
Serialization eff.	99.53%	99.17%	96.07%
Transfer eff.	99.87%	99.66%	97.13%
Comp. scalability	100.00%	99.63%	101.11%
IPC scalability	100.00%	104.87%	107.67%
Instruction scalability	100.00%	100.06%	101.08%
Frequency scalability	100.00%	94.95%	92.91%
Speedup	1.00	3.95	7.62
Average IPC	3.07	3.22	3.30
Average frequency (GHz)	0.84	0.80	0.78
Number of nodes	14	56	112

3D CASE		
Case	original	cputime in C
Global efficiency	81.29%	335.70%
Parallel efficiency	81.29%	89.12%
Load balance	81.75%	90.76%
Communication eff.	99.44%	98.19%
Comp. scalability	100.00%	376.68%
IPC scalability	100.00%	104.97%
Instruction scalability	100.00%	101.69%
Frequency scalability	100.00%	352.88%
Average IPC	3.15	3.30
Average frequency (GHz)	0.81	2.85





Performance Optimisation and Productivity 3

A Centre of Excellence in HPC

Contact:

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 [@POP_HPC](#)

 [youtube.com/POPHPC](https://www.youtube.com/POPHPC)



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