Performance Optimisation and Productivity

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EU H2020 Centre of Excellence (CoE)

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Motivation

Why?

- Complexity of machines and codes

  → Frequent lack of quantified understanding of actual behaviour

  → Not clear most productive direction of code refactoring

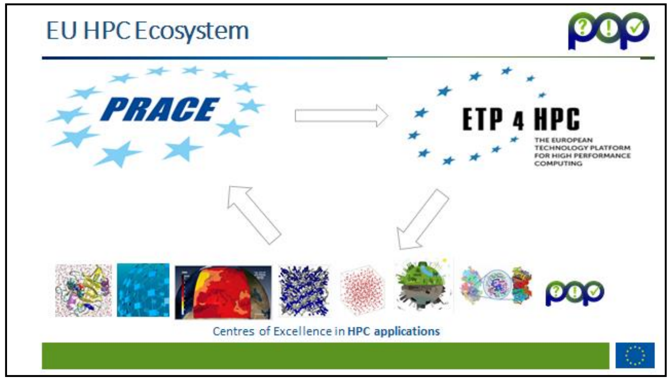
- Important to maximize efficiency (performance, power) of compute intensive applications and productivity of the development efforts

What?

- Parallel programs, mainly MPI/OpenMP
  - Although also CUDA, OpenCL, OpenACC, Python, …

POP CoE

- A Centre of Excellence
  - On Performance Optimisation and Productivity
  - Promoting **best practices in parallel programming**
- Providing 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 academic and industrial codes and users
- **FREE !**



EU HPC Ecosystem

PRACE
ETP 4 HPC
THE EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

Centres of Excellence in **HPC applications**

Services provided by the CoE

? Parallel Application Performance Audit ⇨ Report

- Primary service
- Identify performance issues of customer code (at customer site)
- Small effort (< 1 month)

! Parallel Application Performance Plan ⇨ Report

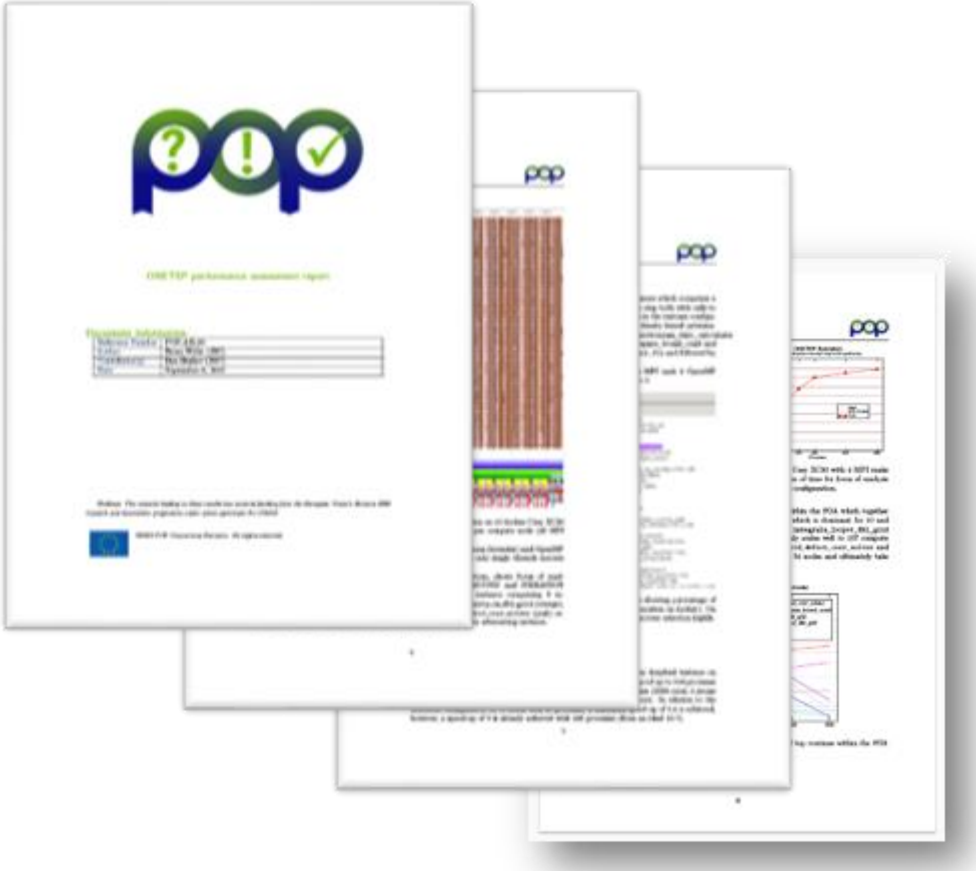
- Follow-up on the audit service
- Identifies the root causes of the issues found and qualifies and quantifies approaches to address them
- Longer effort (1-3 months)

✓ Proof-of-Concept ⇨ Software Demonstrator

- Experiments and mock-up tests for customer codes
- Kernel extraction, parallelisation, mini-apps experiments to show effect of proposed optimisations
- 6 months effort

Outline of a typical audit report

- Application Structure
- (if appropriate) Region of Interest
- Scalability Information
- Application Efficiency
  - E.g. time spent outside MPI
- Load Balance
  - Whether due to internal or external factors
- Computational Performance
  - Identification of areas for improvement
- Communications
  - E.g. sensitivity to network performance
- Summary and Recommendation



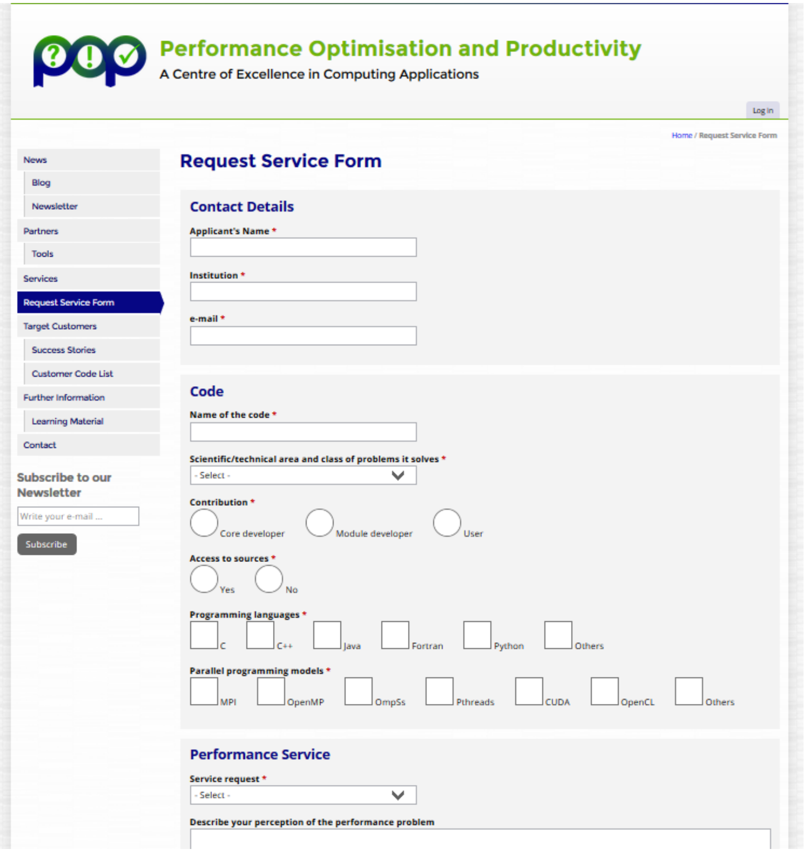
The process …

When?

October 2015 – March 2018

How?

- Apply
  - Fill in small questionnaire describing application and needs https://pop-coe.eu/request-service-form
  - Questions? Ask pop@bsc.es
- Selection/assignment process
- Install tools @ your production machine
- Interactively: Gather data → Analysis → Report



Request Service Form

Contact Details

Applicant's Name *

Institution *

e-mail *

Code

Name of the code *

Scientific/technical area and class of problems it solves *
- Select -

Contribution *
○ Core developer ○ Module developer ○ User

Access to sources *
○ Yes ○ No

Programming languages *
□ C □ C++ □ Java □ Fortran □ Python □ Others

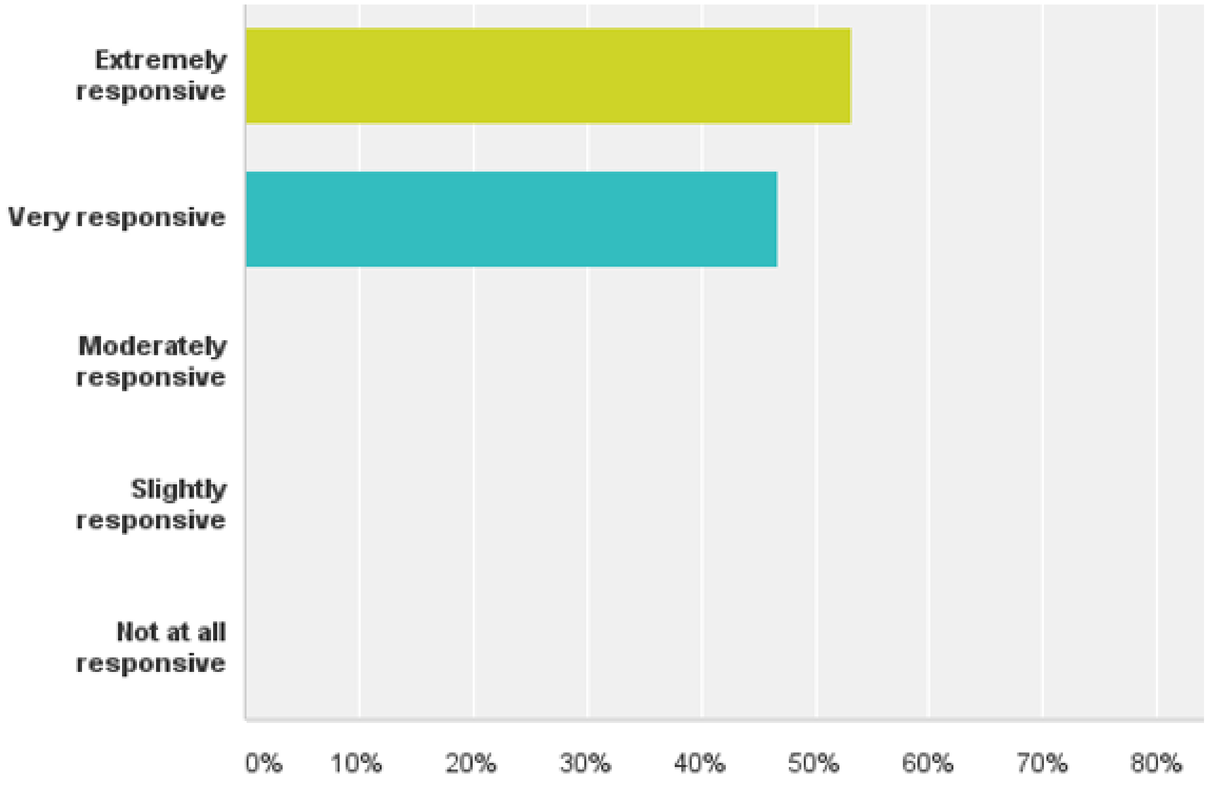
Parallel programming models *
□ MPI □ OpenMP □ OmpSs □ Pthreads □ CUDA □ OpenCL □ Others

Performance Service

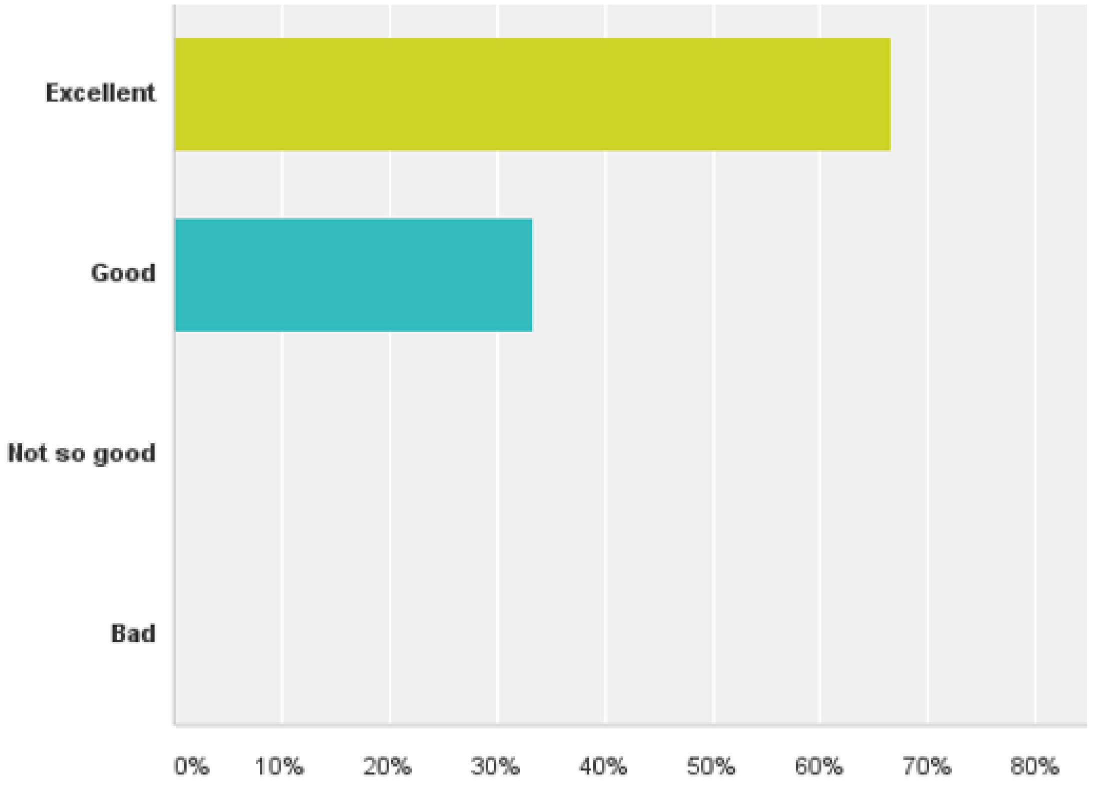
Service request *
- Select -

Describe your perception of the performance problem

Customer feedback



- How responsive have the POP experts been to your questions or concerns about the analysis and the report?



- What was the quality of their answers?

Partners

- **Who?**
  - BSC (coordinator), ES
  - HLRS, DE
  - JSC, DE
  - NAG, UK
  - RWTH Aachen, IT Center, DE
  - TERATEC, FR

A team with

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

Target customers

- **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

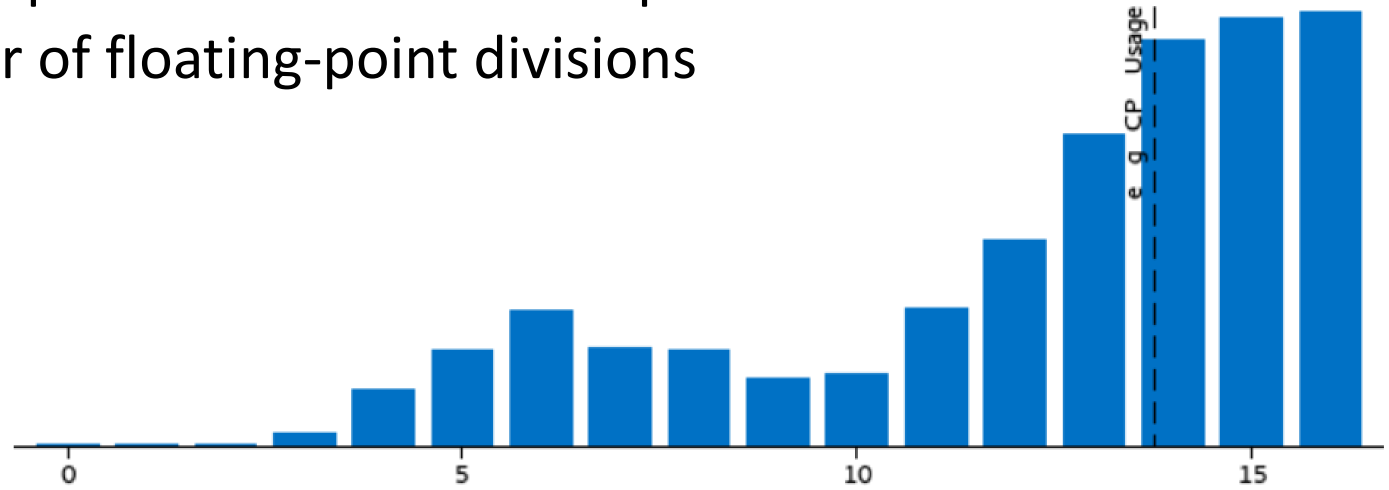
Tools

- **Install and use already available monitoring and analysis technology**
- **Open-source toolsets**
  - Extrae + Paraver
  - Score-P + Cube + Scalasca/TAU
  - Dimemas, Extra-P
  - SimGrid
- **Commercial toolsets** (if available at customer site)
  - Intel tools
  - Cray tools
  - Allinea tools

Code Audit Examples

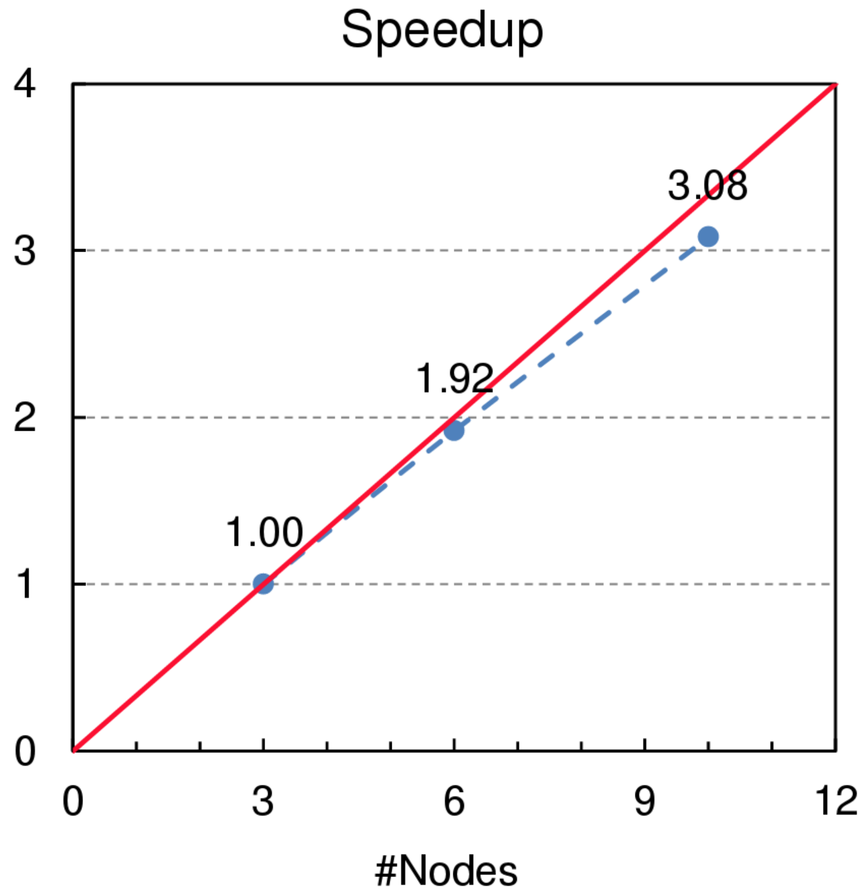
GITM (Cefas)

- An offline particle tracking model code
- Written in Fortran with OpenMP
- Key audit results:
  - Current performance: 16 threads offer 5x speed-up vs 1 thread
  - Load imbalance amongst OpenMP threads
  - Maximise opportunities for vectorisation by aligning arrays and refactoring Fortan array operations to use DO loops
  - Large number of floating-point divisions



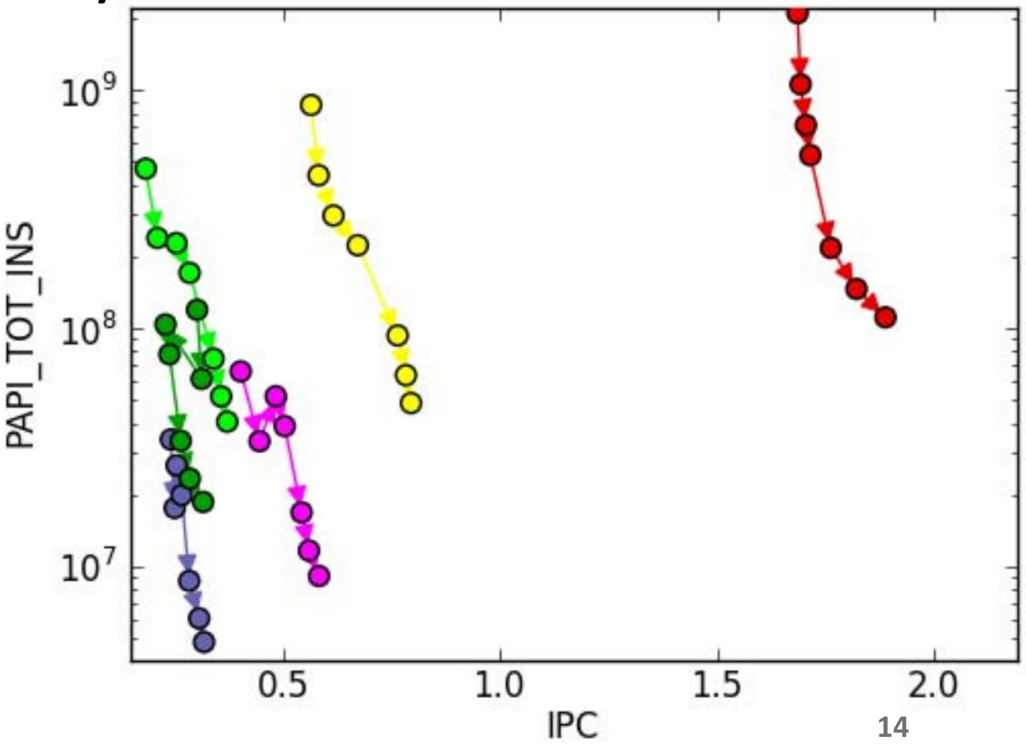
dwarf-D-ellipticSolver-GCR (ECMWF)

- Extracted from ECMWF's Integrated Forecasting System (IFS) code
- Mixed Fortran/C++ code with hybrid MPI+OpenMP
- Key audit results:
  - Good scalability as communication pattern introduces little overhead from synchronisation or serialisation
  - Minor load imbalance due to variability in IPC across nodes
  - Opportunities to further increase performance as IPC is 0.8 on average



NEMO (Atos)

- Undertaken as part of the ESCAPE (Energy-efficient Scalable Algorithms for Weather Prediction at Exascale) project
- Written in Fortran with MPI
- Traces gathered by user and analysed by POP
- Key audit findings:
  - Good computational load balance
  - Observed superlinear speed-up of analysed region of the program, which was due to improved cache efficiency when strong scaling



Other POP activities

- **Customer advocacy**
  - Gather customers feedback, ensure satisfaction, steer activities
- **Sustainability**
  - Explore business models
- **Training**
  - Best practices on the use of the tools and programming models

Performance Optimisation and Productivity

A Centre of Excellence in Computing Applications

Contact:

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