International HPC Summer School 2021: Performance analysis and optimization

VI-HPS Overview

VI-HPS Team
Ilya Zhukov – Jülich Supercomputing Centre

Virtual Institute – High Productivity Supercomputing

- **Goal**: Improve the quality and accelerate the development process of complex simulation codes running on highly-parallel computer systems
- Start-up funding (2006–2011)
  by Helmholtz Association of German Research Centres
- Activities
  - Development and integration of HPC programming tools
    - Correctness checking & performance analysis
  - Academic workshops
  - Training workshops
  - Service
    - Support email lists
    - Application engagement

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

http://www.vi-hps.org

VI-HPS partners (founders)

Forschungszentrum Jülich
- Jülich Supercomputing Centre

RWTH Aachen University
- Centre for Computing & Communication

Technische Universität Dresden
- Centre for Information Services & HPC

University of Tennessee (Knoxville)
- Innovative Computing Laboratory

VI-HPS partners (cont.)

Arm Ltd.

- Allinea Software

Barcelona Supercomputing Center

- Centro Nacional de Supercomputación

Lawrence Livermore National Lab.

- Center for Applied Scientific Computing

Leibniz Supercomputing Centre

Technical University of Darmstadt

- Laboratory for Parallel Programming

VI-HPS partners (cont.)

Friedrich-Alexander-Universität

- Erlangen Regional Computing Center (RRZE)

Technical University of Munich

- Chair for Computer Architecture

University of Oregon

- Performance Research Laboratory

University of Stuttgart

- HPC Centre

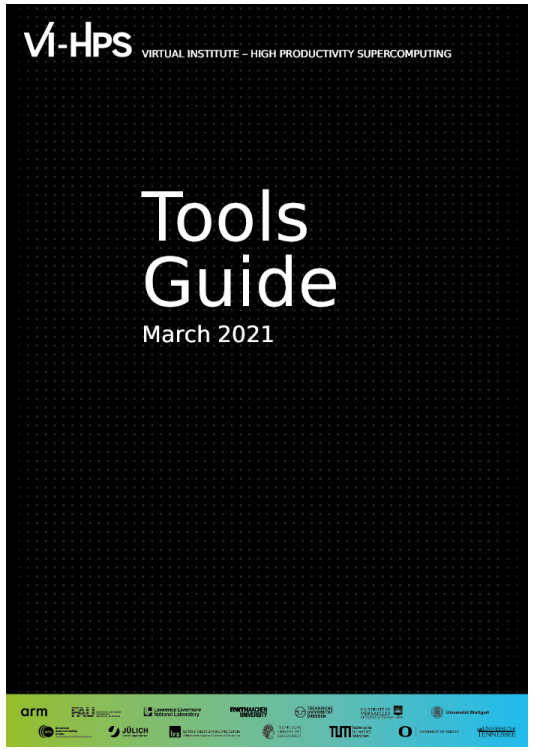
University of Versailles St-Quentin

- Li-Parad

Productivity tools

- **Extra-P**:
  - Automated performance modelling
- **Kcachegrind**:
  - Callgraph-based cache analysis [x86 only]
- **MAQAO**:
  - Assembly instrumentation & optimization [x86-64 only]
- **mpiP/mpiPview**:
  - MPI profiling tool and analysis viewer
- **Paraver/Dimemas/Extrae**:
  - Event tracing, graphical trace visualization & analysis
- **Scalasca**
  - Large-scale parallel performance analysis
- **Score-P**
  - Community-developed instrumentation & measurement infrastructure
- **TAU**
  - Integrated parallel performance system

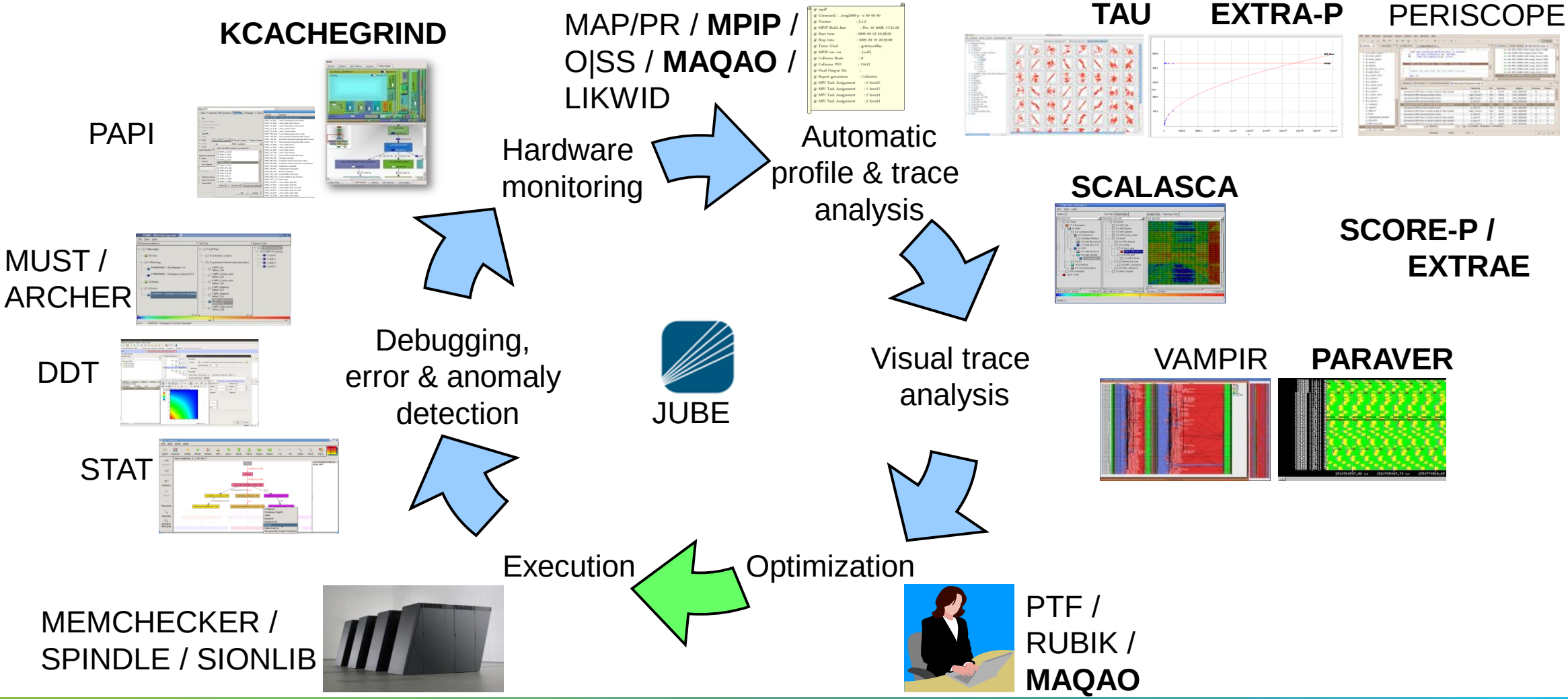
For a brief overview of tools consult the VI-HPS Tools Guide:



Productivity tools (cont.)

- FORGE DDT/MAP/PR: Parallel debugging, profiling & performance reports
- JUBE: Workflow execution environment
- LIKWID: Command-line performance tools suite
- MUST & Archer: MPI & OpenMP usage correctness checking
- Open MPI: Integrated memory checking
- Open|SpeedShop: Integrated parallel performance analysis environment
- PAPI: Interfacing to hardware performance counters
- Periscope Tuning Framework: Automatic analysis and Tuning
- Rubik: Process mapping generation & optimization [BG only]
- SIONlib/Spindle: Optimized native parallel file I/O & shared library loading
- STAT: Stack trace analysis tools
- Vampir: Interactive graphical trace visualization & analysis

Technologies and their integration



Disclaimer

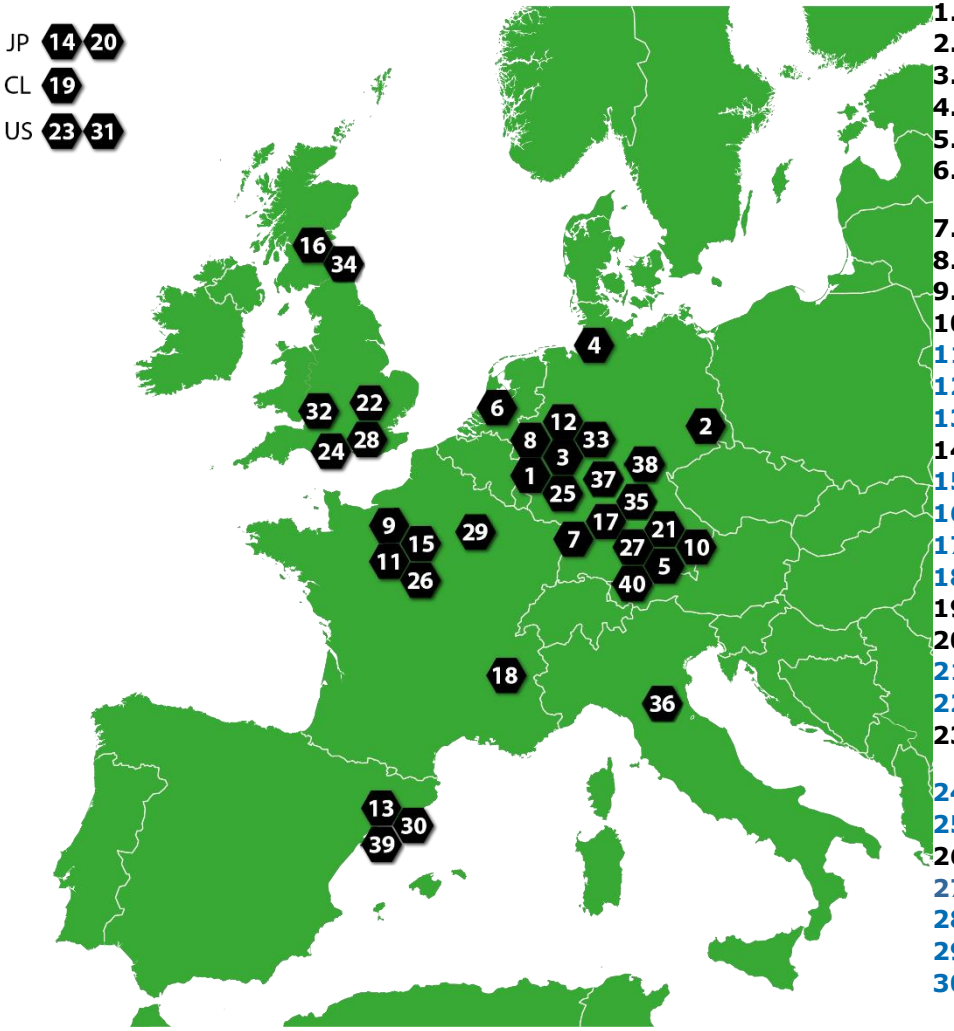
Tools will ***not*** automatically make you, your applications or computer systems more productive.

However, they can help you understand ***how*** your parallel code executes and ***when / where*** it's necessary to work on correctness and performance issues.

VI-HPS training & Tuning Workshops

- Goals
  - Give an overview of the programming tools suite
  - Explain the functionality of individual tools
  - Teach how to use the tools effectively
  - Offer hands-on experience and expert assistance using tools
  - Receive feedback from users to guide future development
- For best results, bring & analyze/tune your own code(s)!
- VI-HPS Hands-on Tutorial series
  - SC'08-11/13/14/15/16/17/19, ICCS'09, Cluster'10, EuroMPI'12/14, XSEDE'13, ISC-HPC'15-19
- VI-HPS Tuning Workshop series
  - 2008 (x2), 2009 (x2), 2010 (x2), 2011 (x2), 2012 (x2), 2013 (x2), 2014(x4), 2015(x3)
  - 2016 (Kobe/Japan, Garching/Germany, Cambridge/UK, Livermore/USA)
  - 2017 (Southampton/UK, Aachen/Germany, Bruyères-le-Châtel/France)
  - 2018 (Garching/Germany, London/UK, Reims/France)
  - 2019 (Barcelona/Spain, Knoxville/USA, Bristol/UK, Jülich/Germany)
  - 2020 (EPCC/Scotland / Online, HLRS/Germany / Online, CINECA/Italy / Online, CSC/Germany / Online)
  - 2021 (NHR@FAU/Germany / Online, POP CoE / ONLINE)

VI-HPS Tuning Workshop series



1. 2008/03/05+3: RWTH, Aachen, Germany
2. 2008/10/08+3: ZIH, Dresden, Germany
3. 2009/02/16+5: JSC, Jülich, Germany
4. 2009/09/09+3: HLRN, Bremen, Germany
5. 2010/03/08+3: TUM, Garching, Germany
6. 2010/05/26+3: SARA, Amsterdam, Netherlands
7. 2011/03/28+3: HLRS, Stuttgart, Germany
8. 2011/09/05+5: GRS, Aachen, Germany
9. 2012/04/23+5: UVSQ, St-Quentin, France
10. 2012/10/16+4: LRZ, Garching, Germany
11. 2013/04/22+4: MdS, Saclay, France
12. 2013/10/07+5: JSC, Jülich, Germany
13. 2014/02/10+5: BSC, Barcelona, Spain
14. 2014/03/25+3: RIKEN AICS, Kobe, Japan
15. 2014/04/07+4: MdS, Saclay, France
16. 2014/04/29+3: EPCC, Edinburgh, Scotland
17. 2015/02/23+5: HLRS, Stuttgart, Germany
18. 2015/05/18+5: UGA, Grenoble, France
19. 2015/10/27+3: NLHPC, Santiago, Chile
20. 2016/02/24+3: RIKEN AICS, Kobe, Japan
21. 2016/04/18+5: LRZ, Garching, Germany
22. 2016/07/06+3: Uni. Cambridge, England
23. 2016/07/27+3: LLNL, Livermore, California, USA
24. 2017/02/08+3: Uni. Southampton, England
25. 2017/03/27+5: RWTH, Aachen, Germany
26. 2017/10/16+5: Lab. ECR, Ter@tec, France
27. 2018/04/23+5: LRZ, Garching, Germany
28. 2018/06/21+3: UCL, London, England
29. 2018/10/15+5: ROMEO, Reims, France
30. 2019/01/21+5: BSC, Barcelona, Spain
31. 2019/04/09+4: UTK-ICL, Knoxville/TN, USA
32. 2019/04/24+3: Uni. Bristol, England
33. 2019/06/24+5: JSC, Jülich, Germany
34. 2020/07/28+3: EPCC, *Scotland* / ONLINE
35. 2020/09/14+5: HLRS, *Germany* / ONLINE
36. 2020/09/30+3: CINECA, *Italy* / ONLINE
37. 2020/12/07+5: CSC, *Germany* / ONLINE
38. 2021/03/01+3: NHR@FAU, *Germany* / ONLINE
39. 2021/04/19+3: POP CoE / ONLINE

Upcoming events

- Tuning Workshop (Autumn 2021, JSC/RWTH, Germany - ONLINE)
  - Focus on GPU
- Further events to be determined
  - (one-day) tutorials: with guided exercises sometimes using a Live-ISO/OVA
  - (multi-day) training workshops: with your own applications on actual HPC systems
- Check **www.vi-hps.org/training** for announced events
- Contact us if you might be interested in hosting a training event

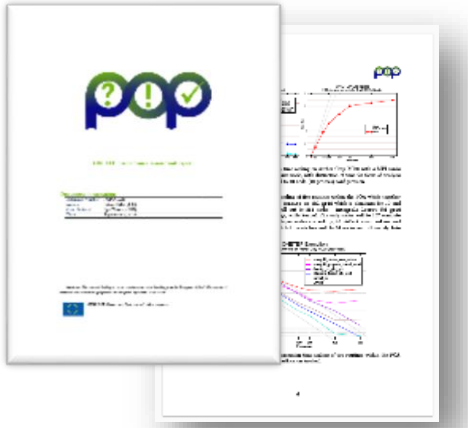
Performance Audits/Plans/Proof-of-concepts

- Performance Optimisation and Productivity (POP)
  - Offers performance optimisation and productivity services
  - Time-limited offer/project
  - Using VI-HPS tools
  - Funded by European Unions Horizon 2020 research and innovation programme
  - https://pop-coe.eu/services

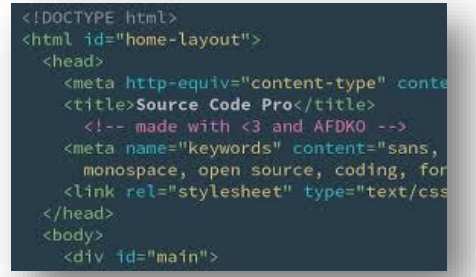
- They help you fix your code, for free!!!

FREE Services provided by the CoE

- **Parallel Application Performance Assessment**
  - Primary service
  - Identifies performance issues of customer code (at customer site)
  - If needed, identifies the root causes of the issues found and qualifies and quantifies approaches to address them (recommendations)
  - **Combines former Performance Audit (?) and Plan (!)**
  - Medium effort (1-3 months)



- **Proof-of-Concept (✓)**
  - Follow-up service
  - Experiments and mock-up tests for customer codes
  - Kernel extraction, parallelisation, mini-apps experiments to show effect of proposed optimisations
  - Larger effort (3-6 months)



Note: Effort shared between our experts and customer!