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Knowledge Alliances

SME/HPC

Enabling SMEs to gain competitive advantage from the use of HPC

D2/1 Assessment framework for the delivery of HPC skills to the private sector organizations

– Didactic methodology –

Prepared by: P4, Ambrosys GmbH

Version: 2.1

Northumbria University NEWCASTLE · FIS Fakulteta za informacijske študije Faculty of information studies · ambrosys · ARCTUR · Press Ltd. Vega · ANCD · UEFISCDI

Document reference

<table>
<tr><td>Project Acronym</td><td colspan="4">SME/HPC</td></tr>
<tr><td>Project Number</td><td colspan="4">588372-EPP-1-2017-1-IE-EPPKA2-KA</td></tr>
<tr><td>Project URL</td><td colspan="4">www.smehpc.eu</td></tr>
<tr><td>EU Project Officer</td><td colspan="4">Silvia.DE-BENEDETTI@ec.europa.eu</td></tr>
<tr><td rowspan="2">Project Coordinator</td><td>Name</td><td>Prof. Bill O'Gorman</td><td>Affiliation</td><td>WIT</td></tr>
<tr><td>Email</td><td>wogorman@wit.ie Phone</td><td>+353.872429537</td><td></td></tr>
<tr><td>Document Name</td><td colspan="4">Assessment framework for the delivery of HPC skills to the private sector organizations - Didactic Methodology</td></tr>
<tr><td>Deliverable Number</td><td colspan="4">D2/1</td></tr>
<tr><td>Type</td><td colspan="2">Document</td><td>Distribution Level</td><td>Public</td></tr>
<tr><td>Responsible Author(s)</td><td colspan="4">P4: Ambrosys GmbH
Dr. Markus Abel, Friedrich Meckel, Katja Schweser</td></tr>
<tr><td>Contractual Date of Delivery</td><td colspan="4">Month 3</td></tr>
<tr><td>Status</td><td colspan="4">Final</td></tr>
<tr><td>Quality assurance readers</td><td colspan="2">Raluca Săftescu | UEFISCDI
Anamaria Ravar | UEFISCDI
Diana Diamescu | UEFISCDI</td><td colspan="2">Martina Golob | ARCTUR
Martina Murovec | ARCTUR</td></tr>
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1. Introduction

SME/HPC is a tailor-made high-performance computing (HPC) education programme for small and medium-sized enterprises (SMEs). HPC allows for big data to be processed with unprecedented efficiency. This emerging technology is a game-changer for both academia and businesses. While most advanced HPC infrastructures and knowledge are located at HEIs and research institutions, enterprises, especially SMEs, have little or no access or competences to use it, in spite of remote access. In fact, few SMEs are aware of the potential of how HPC can drive enterprises' competitive advantage and enhance the levels of innovation capacities, capabilities and practices of SMEs. This leads to both the underutilization of existing expensive infrastructure and the less-than-optimal solving of real-life socio-economic issues. Furthermore, in less developed regions the lack of competences to embrace new technologies, like HPC, leads to a range of adverse conditions such as lower levels of innovation, few patents, low value-add and major brain-drain, which further increases the economic gap and digital divide between European regions. SME/HPC takes a pioneering step towards improving the awareness about the innovative potential of HPC by SMEs by co-designing tailor-made courses delivering a coherent set of competences required for the application of HPC in SME and micro-enterprise contexts. SME/HPC begins with a strategic dialogue yielding an assessment of the required HPC competences, continues with the development of innovative strategies for raising HPC awareness and building HPC skills, and finishes with testing the new educational material with HEIs and enterprises. Three semi-peripheral regions will pilot the SME/HPC methodologies of HEI-Business engagement and the HPC education material.

The key beneficiaries of SME/HPC are enterprises, with a particular focus on SMEs, acquiring both HPC competences and access to hard infrastructure. Furthermore, the positive experience and increased collaborative and cooperative engagement between HEIs and businesses will inspire future co-designing and co-implementation of innovative socio-economic solutions.

1.1 Tool for the analysis of institutional absorptive capacity

The main aim of this work is to establish the readiness and absorptive capacity of HEIs from less developed pilot regions involved in this project as regards their knowledge of High Performance Computing (HPC) and their capability and capacity to deliver HPC programmes to enterprises. Countries involved are Ireland, Romania and Slovenia. Therefore, the aim is to assess the preparedness and interest of the HEIs, in the pilot regions, to undertake the necessary measures for improving the relationships between HEIs and the business sector, particularly in relation to HPC.

The prerequisite for analysing the institutional absorptive capacity is to define an assessment framework for the delivery of HPC skills to the private sector organizations. This involves the detailed presentation of the required knowledge, technology, capability and experience, which HEIs require to transfer HPC knowledge and experience to public an private sector organizations in their respective countries.

The assessment framework will, in a next step, allow for the institutional review of HEIs in the pilot regions to identify the deficits in knowledge, technology, capability and experience. This gap analysis will be specific to each HEI and take country specific conditions into account. At the same time, it enables the assessment of the preparedness and interest of the HEI's in pilot regions to undertake tasks for improving relationships between HEIs and the business sector regarding HPC.

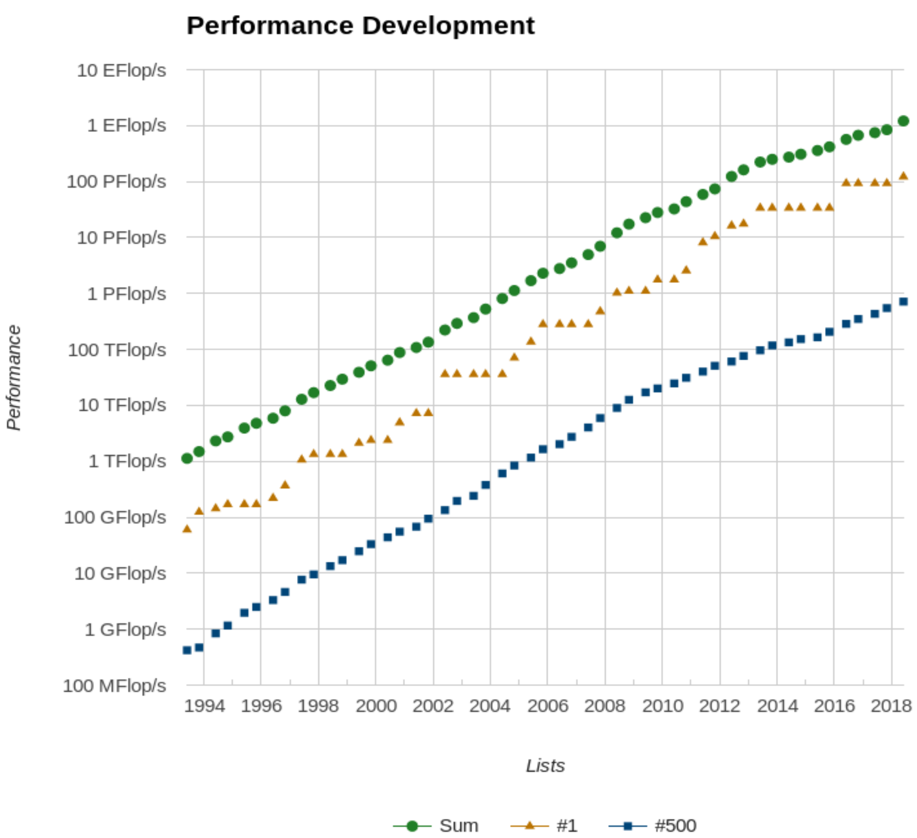
The assessment of the HEIs in the pilot regions - Ireland, Romania and Slovenia - and the identification of deficits results in the setup of institution-specific framework plans, which contain an outline of the required steps needed to narrow the skill's gap. The framework plans shed light on details such as the requested improvement in infrastructure, required competencies and skills, experience, partnerships and alliances. The framework plan also identifies ways how to make these steps in terms of cost-efficiency.

To find out which requirements serve as a basis for HEIs to deliver HPC skills to private sector organizations we conducted a desktop research about successful examples of HEIs which have either a high expertise in scientific HPC or/and have a high developed HPC cluster which might already open their services to enterprises and SMEs in the European Union. Although long-term expertise in the field was of relevance. From that base we derived characteristics for a prepared and persistent HEI which will probably deliver high quality HPC Services in the long-run to its specific region. To get a rounder image of the situation the project is dealing with the research covered additional topics: The HPC landscape of the European Union was investigated, examples for service providers of “High-Performance-Computing as a service” (HPCaaS) were shortly introduced and an HPC centred overview of the peripheral regions of the EU is provided.

2. HEIs and HPC

2.1 Development of HPC

High Performance Computing is a rapidly changing field. Only through the quick adoption of new and promising technology trends, the HPC Community was able to keep up the exponential growth of the computing power (as seen in figure 2.1 [top500-performance])



even though *“the limits of power, available instruction-level parallelism, and long memory latency have slowed uniprocessor performance”*. [HENNESSY & PATTERSON, 2006 p. 3]

Figure 2.1 Top500-Performance

This enduring development was partially achieved by adopting the trend of applying a new supercomputer architecture: the cluster. Several processor units, called nodes, are connected over fast interconnection networks. Whereas the race for the best supercomputer architecture was still pretty much open prior to the early 2000s, the cluster architecture is now the dominating technology used (see figure 2.2 [Top500-Architecture]).

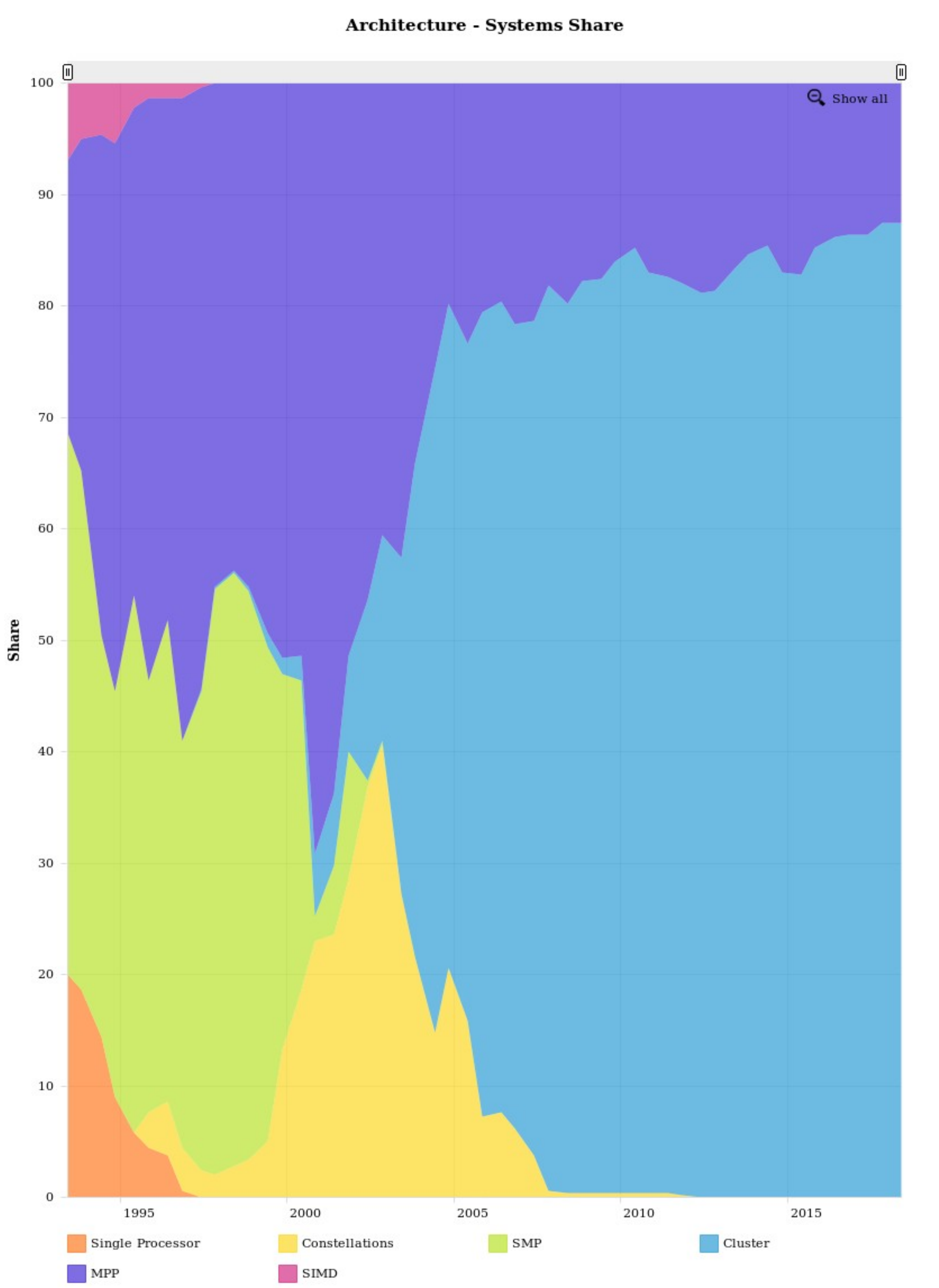


Figure 2.2 Top500-Architecture

Since nowadays most supercomputers are structured as clusters, the technology of the interconnection network has become a field of rapid development, too. The trends and changes in this field are not stable as is shown in figure 2.3 (Top 500-Interconnect Family).

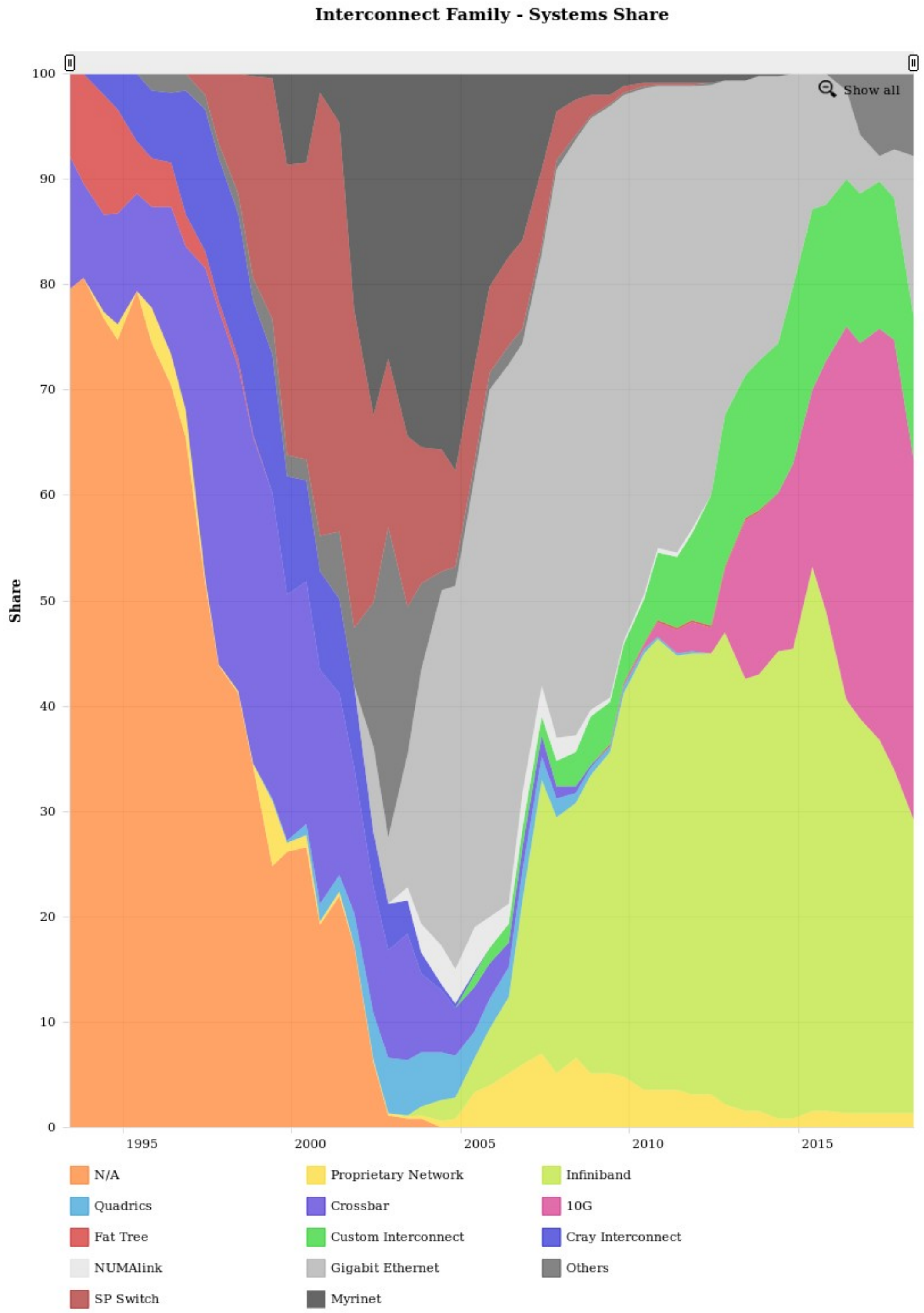


Figure 2.3 Top500-Interconnect Family

However, the greatest changes and developments can be noted in the field of the processor technology. The amount of computing cores per processor is still increasing. Each development requires a new chip architecture resulting in several new processor generations. Since several companies are competing in this field, the processor technology used can be regarded the most unstable part of HPC development as can be seen in figure 2.4 (Top 500-Processor Generation).

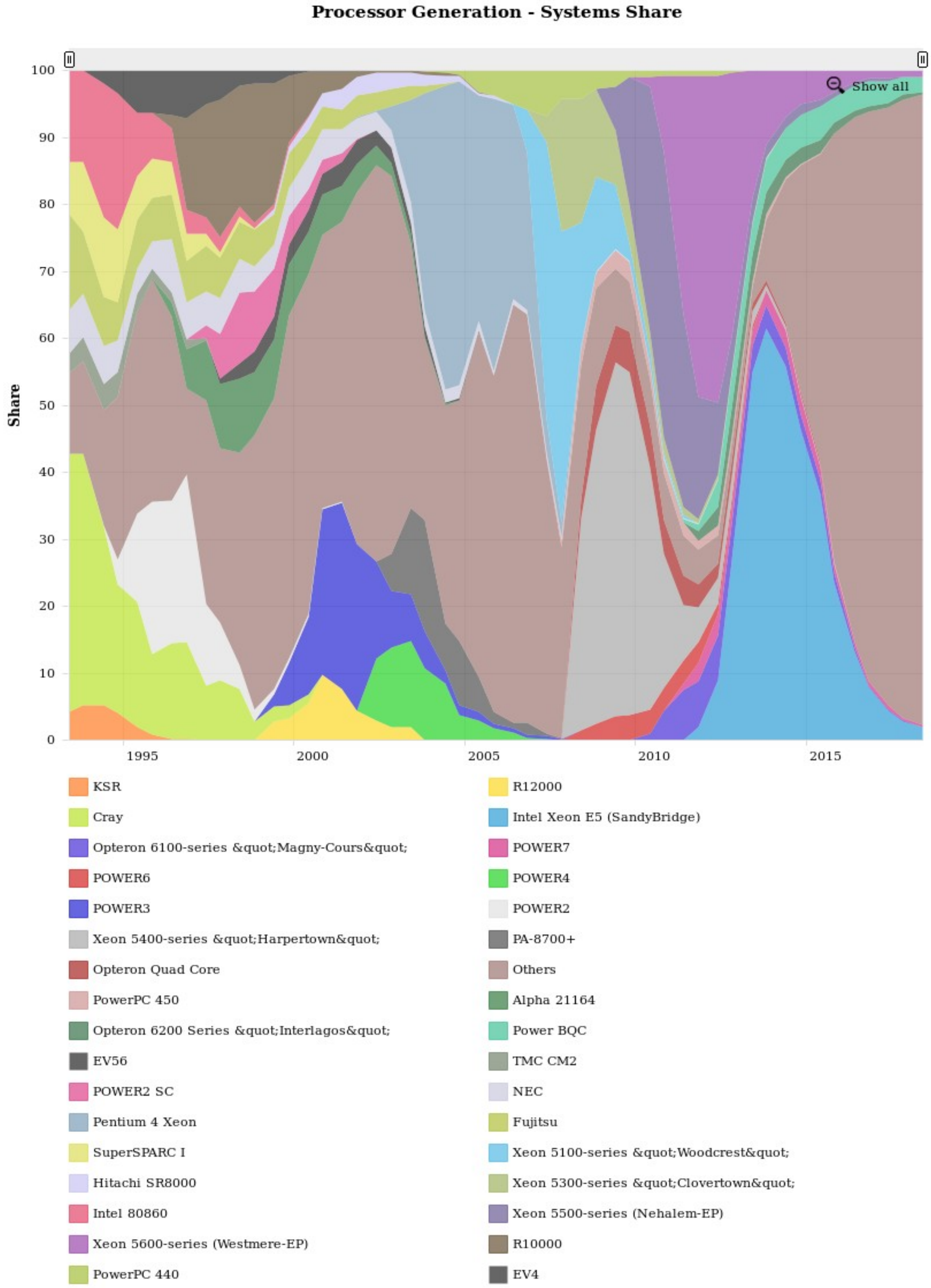


Figure 2.4 Top500-Processor Generation

The charts shown above allow for the conclusion that the technologies applied in the field of HPC will be subject to relatively fast changes in the future also. To tackle this development by developing a general applicable toolkit for HPC clusters is the goal of the project “ProfiT HPC” [„ProfiT-HPC - Raising Awareness of HPC for Performance Engineering“, 2018], which is funded by the German Research Foundation.

2.2 HEI in HPC organizations of the European Union

The HPC landscape of the European Union is organized in the so called HPC-pyramid, which is made up of four Tiers. The main aim is to facilitates the interconnection of the different HPC Centres in Europe and to make it possible to scale up the computational power if needed.

- Tier 3: HPC clusters used by HEI and other public scientific institutions
  - These clusters are rather small and were bought/built to fulfil the specific needs of the scientific research of its owners, often institutes.
  - Example: In Germany, Tier 3 is represented by the ZKI – Centre for communication and information processing - which is the German association of Higher Education (HE) IT centres and publicly funded research organizations. It has more than 250 members [„Mitglieder", 2018], which represent about 90 % of the German HEIs. [„ZKI – centres for communication and information processing", 2018]
- Tier 2: Regional or interregional but specialized HPC Centres
  - Example: In Germany these centres or their controlling institution are mostly organized in the Gauß-Alliance (GA) with 19 members altogether [„HPC Map", 2018] but with only 11 centres with 14 clusters in Tier 2. [„Hardware - Sophisticated technologies in interaction.", 2018]
- Tier 1: National HPC centres
  - These HPC Centres have globally competitive clusters, which means that they are usually in the Top500 list.
  - However, not every country has a HPC Centre with sufficient high-quality equipment as to be counted as a Tier 1 Centre. At the same time, the most powerful centres are organized in Tier 0, so that these two Tiers are overlapping.
  - Example: In Germany there are at least three HPC Centres, which can be regarded being Tier 1 Centres:
    - HPC Centre Stuttgart: one main cluster with 5.640 TFLOPS [„High-Performance Computing Center Stuttgart", 2018]
    - HPC Centre Jülich: two main clusters with 5.000 and 3.800 TFLOPS; currently it is updating its equipment to over 10.000 TFLOPS [„Jülich Supercomputing Centre (JSC)", 2018]
    - Leibnitz HPC Centre: two main clusters with 2.900 and 2.800 TFLOPS [„Leibnitz Supercomputing Center", 2018]

    All three HPC Centres are organized in the support organization Gauß Centre for Supercomputing (GCS) [„GCS Organization", 2018] which is one of the Tier 0 Centres.
- Tier 0: European level
  - This level is organized by the EU project PRACE (Partnership for Advanced Computing in Europe). [„PRACE in a few words", 2018]

- The main aim of the project is not to establish a completely new HPC Centre but rather a more advanced technology interconnection grid among the existing national HPC Centres.

2.3 HPC service providers apart from HEI

There already exist several HPC **as a Service** (HPCaaS) providers on the market. For example,

- Advania (2012) [„The Worlds most flexible and advanced High Performance Computing Service“, 2018]: has access to a Tier 3 and a Tier 1 HPC Cluster
- One Stop Systems (since 1998) [„High Performance Computing (HPC) Applications“, 2018]: offer HPC as a Service, special focus on GPU.
- Cycle Computing (since 2005) [„Cycle Computing accelerates innovation by providing simple, managed access to Big Compute.“, 2018]: bought by Microsoft [„Microsoft acquires Cycle Computing to accelerate Big Computing in the cloud“, 2018]
- Amazon Web Services -AWS (since 2006) [„Amazon Web Services“, 2018]: has a “high potential for medium sized parallel compute problems which are typically present in industrial engineering applications” [Zaspel & Griebel, 2011]
- fortissimo-project.eu [„The Fortissimo Marketplace“, 2018]: provider for HPC high level simulation solutions supported by the EU; SME\HPC partner Arctur has participated in that project, too [„Arctur“, 2018]

2.4 Successful HEI Examples

The following section focuses on examples of HEIs from the core area of the technological landscape of the current EU, which is mostly made up of the blue banana.[1] Most examples are from Germany with further examples from Great Britain. In addition, the Princeton University (USA) and the Shanghai Jiao Tong University (China) were taken into account. Moreover, there will be mention of noteworthy examples, which were found when doing this research.

TU Berlin - Technische Universität Berlin

The TU Berlin does not have a centrally organized HPC Cluster but several smaller institutes and departments, which have smaller clusters at their disposal, however, no commercial use is allowed. These are the following:

- The Institute for Mathematics [„Institute of Mathematics - Computeserver“, 2018] has eleven small to medium clusters with different architectures and technologies with 8 to 40 nodes and 16-80 cores. It provides clusters for each processing unit focus: Intel-CPU, AMD-CPU and GPU. All clusters might be used as one heterogeneous HPC resource.
- The Department for Dynamics of Maritime Systems [„Rechencluster des FG DMS“, 2018] has one cluster with 18 computation nodes with 248 cores.
- The Robotics and Biology Laboratory [„Infrastructure“, 2018] has one workstation HPC with 4 GPU cards for Deep Learning applications.

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1 The term “blue banana” describes the highly populated corridor of industry and services stretching from northern England to northern Italy passing over the Benelux and the Rhine area covering several european metropole areas.

- The Helmholtz Center [„Hardware and user environment“, 2018] is associated with the TU Berlin and offers courses to university students. It offers eight AMD-CPU clusters with 1-13 nodes and 16-832 cores.

The TU is currently installing a bigger HPC Unit for 1.6 million Euro. The intention is to be as diverse as possible in hard and software while remaining one integrated system. [„Beschaffung eines HPC-Systems für die Technischen Universität Berlin“, 2018]

All in all, there is no TU institute or department specialized in HPC in particular, but several departments participate in projects or offer projects with regard to HPC (Working-group Embedded Systems Architecture [„Current Projects“, 2018]). One department, moreover, offers HPC modules (Lectures on “Cluster Computing” and “Parallel Programming” [„Module: Parallel Systems“, 2018]).

RWTH Aachen University

The RWTH Aachen is the biggest University in Germany with a main focus on technology with over 40.000 thousand students. It has a reasonable single Cluster System, which was on rank 488 in the November 2017 Top500. [„Top500 List - November 2017“, 2018] When the capacity is insufficient, the RWTH Aachen offers the connection to the Gauß Center for Supercomuting (see “National Powerhousing - Gauß Center for Supercomputing – GCS” below). The cluster system can only be used for University and other scientific purposes.

The University established a professorship on HPC [„High Performance Computing“, 2018a], which offers several modules specialized on HPC. [„High Performance Computing“, 2018b]

Shanghai Jiao Tong University

The Shanghai Jiao Tong University has established an HPC Centre together with its partners NVIDIA, Intel, CAPS enterprise, Inspur and AMD, which was founded in 2013. [„About Center“, 2018] It was ranked in the Top500 last in June 2015 with 196 TFLOPS at rank 384. [„Top500 List - June 2015“, 2018] However, it seems that the HPC hardware has only been slightly updated since then being at 343 TFLOPS at the moment. [„Cluster Hardware Information“, 2018]

Princeton University

Princeton University is engaged in a powerful HPC Research Centre, which is supervised by the Princeton Facility Unit. This Unit is uncoupled from the institutes and apparently organizes the access to the facilities and the HPC Centre in a relatively independent manner. [„About facilities“, 2018] The institutes rather accesses HPC resources from the HPC Centre instead of maintaining their own HPC cluster. The Facility Unit employs its own personnel to manage the usage and maintenance of the HPC resources and to introduce newcomers to the technology.

The centre itself offers the major cluster “Tiger”, which is made up of two parts (one CPU-GPU mixed and one with CPU focus, 1500 TFLOPS each), and several additional smaller clusters. [„High-Performance Computing Research Center“, 2018] The Princeton Institute for Computational Science and Engineering (PICSciE) has no special department dedicated to HPC but is engaged in many interdisciplinary projects about the topic. [„High-Performance Computing“, 2018]

University of Cambridge

The University of Cambridge has a long history in HPC and has been engaged in this field since 1998. It has also organized its HPC resources in a mostly faculty independent HPC Centre, which is run by the Scientific Computing Support. [„Cambridge Service for Data Driven Discovery“, 2018] This centre also provides HPC as a service [„The CSD3 Platform“, 2018] and created a new joint platform in 2017 for 14 million Pounds Sterling. [„Cambridge Service for Data Driven Discovery“, 2018]

The centre has two major clusters, a CPU cluster (ranked 75 in Top500 November 2017 with 1.697 TFLOPS), and a GPU focused cluster (ranked 115 in Top500 November 2017 with 1.193 TFLOPS). [„Top500 List - November 2017“, 2018] In addition, there exists a number of small clusters at the HPC Centre, which can be accessed exclusively by other institutes.

Other HPC examples worth mentioning

Experience at Potsdam Institute for Climate Impact Research (PIK)

The IT-Services Group operates a high-performance cluster computer for scientific calculations (numerical simulation experiments) since 1993. [„HPC Service Overview“, 2018] Its HPC cluster was at rank 483 in the November 2015 Top500 list. [„Top500 List - November 2015“, 2018]

ZIM at Potsdam University

The ZIM (Centre for Information Technology and Media Management) at Potsdam University supports University members to use their cluster and to contact the HLRN (North-German union for HPC [„Willkommen beim HLRN“, 2018]) to use their superior computing power. [„High Performance Computing (HPC)“, 2018]

Wiki from Heinrich-Heine-Universität Düsseldorf

The HHU Düsseldorf is not the only University with an extra wiki dedicated to explain the usage of its HPC resources. However, its wiki is exemplary since it is uncomplicated and straight forward. [„Wissenschaftliches Hochleistungs-Rechnen am ZIM“, 2018]

Regional University Union in Wales

Supercomputing Wales - the national supercomputing research facility for Wales [„The national supercomputing research facility for Wales“, 2018] - was made possible by a union of the four biggest Universities in Wales: Cardiff, Swansea, Bangor and Aberystwyth. Together they were successful in collecting funds of 15 million Pounds Sterling to establish its own HPC Centre. This centre offers project collaborations with commercial partners. [„About Supercomputing Wales“, 2018]

Tightly Separated HPC at HPC Center of Stuttgart University

The University of Stuttgart, like Cambridge and Princeton, separated its HPC by bundling its resources into a single organizational structure, the HPC Centre founded in 1996. [„High-Performance Computing Center Stuttgart“, 2018] At the same time, the HPC Centre is tightly coupled with the University trough overlapping personnel: the Director of the HPC Centre is at the same time professor for HPC at the University and chairman of the HPC dedicated Institute. [„Organigram“, 2018]

The HPC Centre used to offer its services to German researchers and industry only, but opened it to European users in 2010 by means of the PRACE project, the Partnership for Advanced Computing in Europe. [„High-Performance Computing Center Stuttgart“, 2018] The focus on providing services is also manifested in the website of the HPC Centre since it has a section which is dedicated to enterprises and SMEs with a special focus on consulting, training and examples. [„Enterprises & SME“, 2018]

National Powerhousing - Gauß Center for Supercomputing - GCS

The Gauß Center for Supercomputing [„GCS Home“, 2018] is the organizational superstructure for three of the most powerful HPC Centres in Germany which accumulate to more than 20.000 TFLOPS, which would rank around 3 or 4 in the Top500 November 2017. [„Top500 List - November 2017“, 2018] The following HPC Centres are engaged in the GCS:

- HPC Center Stuttgart (one main cluster with 5.640 TFLOPS) [„High-Performance Computing Center Stuttgart“, 2018]
- HPC Centre Jülich (two main cluster with 5.000 and 3.800 TFLOPS) [„Jülich Supercomputing Centre (JSC)“, 2018]
- Leibnitz HPC Center (two main cluster with 2.900 and 2.800 TFLOPS) [„Leibnitz Supercomputing Center“, 2018]

Conclusion: beneficial properties for HEI

All HEIs which have opened their HPC capacities to commercial partners or offer HPC collaborations have bundled up their HPC resources in a single HPC Centre (Princeton, Cambridge, Stuttgart, Supercomputing Wales).

There are also examples of HEIs, which do not have high class HPC resources. However, to overcome this insufficiency, they interconnect with the national HPC landscape (Potsdam and the HLNS, Aachen and the GCS/PRACE).

It also appears that HPC Centres having one or more main clusters tend to focus on different processor types. There is also a trend that a HPC Centre has one or two main clusters with different processor focus. These main clusters are accompanied by smaller clusters with more specialized technology and/or architecture.

Several HEIs in Germany have recognized the importance of HPC and established professorships dedicated to it (a selection):

- RHTW Aachen [„High Performance Computing“, 2018a]
- Stuttgart University [„Organigram“, 2018]
- Friedrich-Alexander-University Erlangen-Nürnberg [„High Performance Computing @ FAU“, 2018]
- University of Duisburg-Essen [„People“, 2018]

2.5 Examples for the HPC landscape of the Peripheral Regions of the EU

Ireland

In Ireland all of the seven strongest HPC clusters are owned by an unknown Company. The best HEI connected HPC clusters are accessible via the Irish Centre for High-End Computing

[„Irish Centre for High-End Computing | ICHEC“, 2018], which is located both in Dublin (East coast) and Galway (West coast). But the centre is facing problems of computational competitiveness: with only 147 TFLOPS, the FIONN main cluster was last ranked at 476 in June 2014 in the Top500. [„Fionn“, 2018][„Top500 List - June 2014“, 2018] Nevertheless, its replacement with over 660 TFLOPS, which is currently being built for 5.4 million euro, will not be enough to get the Irish Centre for High-End Computing back on the Top500 list. [„Top500 Supercomputers List Exposes Ireland’s Continued Decline in Global Competitiveness“, 2018]

In general, its services are provided exclusively for scientific parties. However, the centre also participated in the EU Sesamenet project [„SESAME Net“, 2018], which aimed at connecting enterprises and SMEs with HPC competence centres, the Irish Centre for High-End Computing being one, too.

Apart from that, from the HEIs in the Southern region of Ireland, which is the SME\HPC region of interest, it is only the University College Cork (UCC) that has a pay service for its members to use a 48 CPU strong cluster. [„Research Cloud Infrastructure“, 2018]

Slovenia

In Slovenia, the Faculty of Mechanical Engineering at the University of Ljubljana has established a HPC Centre. [„Visokozmogljivi računski sestav HPCFS“, 2018] It is the Slovenian HPC partner of PRACE. [„ULFME – University of Ljubljana, Faculty of Mechanical Engineering“, 2018]

However, Slovenia is the home of an advanced HPCaaS provider from the private sector, Arctur [„Arctur - Home“, 2018], which offers access to a cluster from a Chinese vendor with several pre-installed environments. [„Arctur - web store“, 2018]

Moreover, the Institute Jožef Stefan (IJS [„Institute Jožef Stefan“, 2018]) offers scientific access to several smaller clusters.

Romania

The NCIT High Performance Computing Center of the Computer Science Department from the Faculty for Automatic Control and Computers at the University Politehnica of Bucharest offers access to several smaller clusters with different processor technologies. It also provides access to commercial parties. [“NCIT – Home”, 2018]

There is also the HPC Centre at the Timisoara University [„HPC Center at UVT“, 2018], which lacks in competitiveness as compared to the core regions. Its most powerful cluster has only 11.7 TFLOPS and is stated as being the fastest supercomputer of Romania. [„BlueGene/P“, 2018] However, the university had problems achieving a satisfactory level of operation grade. [„Supercomputer, folosit la 30“, 2014]

Bulgaria

The Institute of Information and Communication Technologies (IICT) at the Bulgarian Academy of Sciences has a reasonably strong cluster [„Supercomputer System Avitohol at IICT-BAS“, 2018], which was last on rank 389 of the November 2015 TOP500. [„Top500 List - November 2015“, 2018] The University also participated in the Sesamenet project to couple HPC competence centres with SMEs.

3. SMEs - Present and Future

3.1 Usage Scenarios for HPC

The possible usage scenarios for HPC resources cover a wide range of topics. Already in 1989, Dr. Sheryl Handler indicated the range of possible topics: *"Supercomputers [...] shrink oceans, zoom in on molecules, slow down physics, and fastforward climates".* [BROWN u. a., 2000 p. 254] The wide range of usage scenarios contributes to making HPC a desired instrument for a wide range of industrial applications. This is of interest for many enterprises and especially SMEs, too.-However, in general, they cannot afford high HPC expertise and capacities in-house.

Main areas of recent HPC usage

Grand Challenges (Basic Research)

- Decoding of genomes [„Whole-Genome Sequencing Simulated on Supercomputers“, 2018]
- Global Climate Changes [„Earth Simulator“, 2018]
- Biological Macro molecules *"Automated data acquisition on a high-end microscope can yield several terabytes of images every day, and processing times may run into hundred thousands of computing core hours per data set. To avoid buying and maintaining costly high-performance computing infrastructure, alternative solutions such as cloud computing and implementation of image processing algorithms on cheaper graphical processing units (GPUs) are being explored."* [FERNANDEZ-LEIRO & SCHERES, 2016]

IT Infrastructure

- Data Mining [GROSSMAN & GU, 2008]
- Machine Learning [CATANZA, 2015]: the quality of Machine Learning often depends on model size and data size because:
  - Bigger models are usually better.
  - More data is usually better.
  - With HPC both aspects can be increased.

Product development

- Fluid mechanics [LAWSON u. a., 2012]
- Drug design [LIU u. a., 2016]
- Chip design [KRISHNAPURA u. a., 2013]
- Computer-aided design (CAD): The working time of product engineers and designers can be used more effectively as simulations become more realistic/adequate and in a real-time manner. [HPC-COUNCIL slide 11]
  In this case:
  - (Realtime) simulation of product design
  - (Realtime) simulation of product physics, including
    - Crash tests

        - metal casting
    - material minimization while meeting the same physical product goals

become tasks also requiring HPC resources.

Virtual Reality

- Rendering [„HPC as a Service for High Performance Video Rendering“, 2018]
- Virtual/Augmented Reality (one of the biggest German HPC Centres, the HLRS, has a tab on its website for these services [„Visualization“, 2018])

Conclusion: applicability of HPC for SME

While the grand challenges like simulating the global climate and processing the data of the worlds best microscopes might still not be in the range of uses for SMEs, *“Many SMEs rely on modelling and simulation for their business and could benefit from access to HPC.”* [„How using HPC can help businesses compete in today’s world“, 2018] The progress in computational fluid dynamics and physical and mechanical simulations and the ways, in which these models can be applied through the use of HPC resources, provide a possible strategic advantage for any SME, which develops new products, special machines, special machine parts or is involved in forecasting developments in causality environments. In Addition, the recent trend to apply Machine Learning to a wide range of problems will step up to these possible advantages.

SMEs which are not interested or not aware of the possibility to make use of HPC will have competitive disadvantages as compared to SMEs, which apply HPC. Moreover, this gap becomes even more apparent especially when comparing the peripheral regions with the central regions of the technology landscape in the EU, which makes the necessity to close the gap in HPC expertise and capacity an urgent matter.

3.2 Successful SME Examples

SMEs do not have the financial capacities to run their own HPC Cluster. Additionally, SMEs cannot afford to teach an employee over years how to use HPC. To provide both, expertise and capacity, to SMEs is often referred to as “HPC as a Service” (HPCaaS).

The diversity of HPCaaS was researched as a side product of the Fortissimo project, which is funded by the EU. [„The Fortissimo Marketplace“, 2018] The project created a marketplace, which unites the experts to find the right solution for a demanded task and the HPC-providers fit that task. This way, it is a one-stop-shop for the demands of enterprises and SMEs, which are often related to modelling and simulation. Fortissimo presents 55 success stories on their website of which 5 are named here to represent the diversity of their portfolio.[2]

Alstom Ferroviara

Alstom Ferroviara is the Italian branch of the multinational Alstom Transport company specializing in the railway sector. With the help of Fortissimo it created a new HPC based diagnosis monitoring tool to predict maintenance needs for turnouts, one of the basic and crucial parts of the railway infrastructure. This new system was developed faster with HPC and will probably save 280k euro per year. [„Alstom Ferroviara“, 2018]

2 It shall be noted, however, that Fortissimo does not state how many of the application experiments were done after the project time ended (within project time it had been 53) and how many of them did not have a successful outcome. Based on the success-story-urls there have been at least 713 stories on the whole. Moreover, two of the success stories are about the same SME, Koenigsegg, without stating what exactly the difference is, besides changed HPC partners.

EnginSoft

EnginSoft is an Italian SME and specialized in the development and production of centrifugal pumps. Since Simulation became cheaper than physical experiments the accuracy of the simulation is highly important. The use of HPC resources and consulting services provided by a Fortissimo vendor resulted in speeding up the design and optimization process by a factor of 4 to 6 times. [„EnginSoft“, 2018]

Koenigsegg

Koenigsegg is a Swedish car producing SME for very special and limited sport cars. It is therefore in need of extensive air flow testing for each new model. *“Using HPC allowed Koenigsegg to avoid wind tunnel testing altogether in the development of their new ‘megacar’, the One:1. Using Fortissimo’s services contributed not only to a reduction in Koenigsegg’s costs, but also allowed the car to be brought to market quicker than expected through a 30% reduction in time-to-market compared with previous cars.”* [„How using HPC can help businesses compete in today’s world“, 2018]

Numtech

Numtech is a French SME specialized in air-quality and meteorological simulations. With the help of Fortissimo partners they successfully applied their expertise to new software tools which are able to forecast air-quality up to city-scale. [„Numtech“, 2018]

Oxolutia

Oxolutia is a Spanish high technology SME and a *“spin-off company derived from the Institute of Materials Science of Barcelona (ICMAB)”.* [„About Us“, 2018] It successfully uses an advanced physical simulation of material properties under mechanical stress and electromagnetic influences to develop new High-temperature superconductors for the industry. [„Oxolutia“, 2018]

3.3 Perspectives for Peripheral Regions

The diversity shown by the areas of HPC application and the examples of successful linkage between SMEs and international HPC providers, through the Fortissimo project, demonstrates the benefits of using HPCaaS. It also highlights the fact that SMEs in peripheral regions can also use HPC successfully to gain competitive advantage. This would help to face the widening advantage gap between SMEs using (more probable in the central EU regions) and not using HPC (more probable in the peripheral regions), which Fortissimo does in some aspects.

However, the Fortissimo project does not focus on the differences between peripheral and central regions, rather it focuses on providing HPC expertise, capacity and capability to SMEs regardless of their location. But in order to take advantage of this opportunity, SMEs must be made aware of HPC and the potential advantages it brings to their businesses. In particular, SMEs located in peripheral regions generally do not have the resources to have their own HPC facilities, therefore they must rely on engaging with HPCaaS providers based in technology centres. To test and start a pure HPCaaS environment the EU has already completed one Fortissimo project [„The Fortissimo Marketplace“, 2018] and started two programmes (Sesamenet [„SESAME Net“, 2018] and Fortissimo 2 [„The Fortissimo 2 Project“, 2018]) within the frame of Erasmus+.

The purpose of the SME/HPC project is to raise the awareness and application of HPC and HPCaaS to peripheral regions. That also includes the evaluation of the HEI in peripheral regions regarding HPC and HPCaaS. It will be of major benefit and competitive advantage to peripheral regions if they can generate HPC knowledge, expertise, capacity and capability within their region. That supports the emergence of HPCaaS providers and SMEs using HPC or HPCaaS in their specific region at the same time. A source of HPC knowledge and expertise for those SMEs is the HEI(s) that exist in a given region. Therefore, these HEIs need to have the capacity and capability to transfer knowledge about HPC and its application to SMEs within their regions.

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5. Glossary

Term	Explanation
TOP500	List of the 500 fastest supercomputers/ cluster systems. The list is updated twice a year in June and November.
TFLOPS	Tera FLOPS – Measure for supercomputers (1 Trillion = 10^12 floating point operations)
CPU	A general processing unit; can process a wide range of operations but is relatively slow.
GPU	Specialised Processing Unit – Only able to process certain operations bot those far more efficient.
Accelerator	Alternative term for GPUs used in clusters
HPCaaS	HPC as a Service
Homogeneous HPC Cluster	An HPC Cluster of which the nodes are all of the same architecture and use the same technology, the interconnection network between the nodes is structured in a particular way assuring several properties for message times.
Heterogeneous HPC Cluster	An HPC Cluster of which the nodes might differ in the count of processors and cores per node and although the interconnection network might not be structured. It is furthermore possible to combine several homogeneous clusters into one bigger heterogeneous cluster.