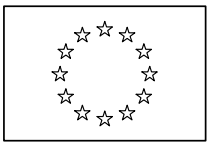

EUROPEAN COMMISSION

Brussels, 15.2.2012
COM(2012) 45 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

High-Performance Computing: Europe's place in a Global Race

1. PURPOSE

This Communication highlights the strategic nature of High-Performance Computing (HPC) as a crucial asset for the EU's innovation capacity, and calls on Member States, industry and the scientific communities, in cooperation with the Commission, to step up joint efforts to ensure European leadership in the supply and use of HPC systems and services by 2020.[1]

This Communication follows the Communication on ICT Infrastructures for e-Science and the conclusions of the Council asking for 'further development of computing infrastructures such as the Partnership for Advanced Computing in Europe (PRACE)[2]' and to pool 'investments in high-performance computing under PRACE, in order to strengthen the position of European industry and academia in the use, development and manufacturing of advanced computing products, services and technologies'.[3]

2. HIGH-PERFORMANCE COMPUTING: WHAT FOR?

The race for leadership in HPC systems is driven both by the need to address societal and scientific grand challenges more effectively, such as early detection and treatment of diseases like Alzheimer's, deciphering the human brain[4], forecasting climate evolution, or preventing and managing large-scale catastrophes, and by the needs of industry to innovate in products and services.

97% of the industrial companies that employ HPC consider it indispensable for their ability to innovate, compete, and survive[5]. HPC has enabled automakers to reduce the time for developing new vehicle platforms from an average of 60 to 24 months, while greatly improving crashworthiness, environmental friendliness, and passenger comfort. Some of these firms have cited savings of EUR 40 billion from HPC usage. HPC lies behind the weather forecasts we rely on to plan our daily activities and to deal with severe weather conditions that can devastate lives and property. Hospitals in Germany use HPC to predict which expectant mothers will require surgery for Caesarean births, with the goal of avoiding traditional, riskier

---

1 High-performance computing (HPC) is used in this Communication as a synonym for high-end computing, supercomputing, world-class computing, etc., to differentiate it from distributed computing, cloud computing and compute servers.
There's no fixed definition of how powerful a computer needs to be for it to be considered as 'high performance'. This is because the performance of microprocessors has increased exponentially for many years, so any such definition is out of date quickly. It's usual to consider a computer to be high performance if it uses multiple processors (tens, hundreds or even thousands) connected together by a network to achieve the performance well above that of a single processor. Using multiple processors in this way is sometimes called parallel computing. The best performing machines in 2010 use hundreds of thousands of processing cores and are capable of 10^{15} floating point operations per second (this is referred to as a 'peta-flop'). This is 1000 times more than the most powerful machine delivered in 2000, which in turn was 1000 times more powerful than a decade earlier. Experts predict that exa-scale computers (capable of 10^{18} operations per second) will be in existence by 2020.

2 PRACE: www.prace-ri.eu

3 COM(2009) 108; Council Conclusions (17190/09) and (9451/10)

4 E.g. The Virtual Physiological Human initiative, www.vph-noe.eu
The Human Brain Project, www.humanbrainproject.eu

5 IDC (International Data Corporation) Studies 'A Strategic Agenda for European Leadership in Supercomputing: HPC 2020' and 'Financing a Software Infrastructure for Highly Parallelised Codes'

last-minute decisions during childbirth. Thus, HPC is vital for the EU's industrial capabilities as well as for its citizens.

At a macroeconomic level, it has been shown that returns on investment in HPC are extremely high and that the companies and countries that invest the most in HPC lead in science and economic success. Furthermore, advances in the area of HPC such as new computing technologies, software, energy efficiency, storage applications, etc. feed into the broader ICT industry and the consumer mass market, becoming available in households within five years of their introduction in high-end HPC. Conversely, advanced computing technologies developed for the consumer domain (e.g. energy efficient chips, graphic cards) are increasingly used in HPC.

3. EUROPE'S HIGH-PERFORMANCE COMPUTING MARKET

Europe has strengths in the application of HPC, and in the development of advanced software and services. Despite this, EU HPC suppliers held a market share of only 4.3%[5] in 2009. Most EU HPC manufacturers had disappeared by the start of the new millennium. Since then US-manufactured supercomputers have captured 95% of the EU market.

The HPC demand comes from three main groups: the governmental sector addressing strategic national security issues; the public research and innovation sector consisting of computing centres mainly associated with universities or as centralised national entities; and industry. In terms of market size, the EU market for high-end HPC systems is relatively small: some EUR 630 million in 2009 but growing worldwide at a compound annual growth rate (CAGR) of 3% since 2005. Some two thirds of this market depends on public funding. The broader global HPC market (HPC systems, storage, middleware, applications and services) was worth EUR 14 billion — with some 32% in Europe — in 2010 and had a CAGR of 7.5%.[5]

In terms of HPC capacity deployed, the EU lost 10% of its high-end computing capacity from 2008 to 2010, whereas other nations increased their efforts in this area during the same period. In 2011, the US and Japan each had more HPC capacity than all EU countries combined[6], and China had more capacity than any individual Member State. China and Russia declared HPC an area of strategic priority and massively increased their efforts. Fewer high-end computing resources available in the EU mean that scientific know-how which critically relies on HPC and influences the development of new HPC systems, is weakening in Europe. Scientists may relocate to conduct their research in other world regions with better environments for HPC.

The EU has many successful scientific and engineering software firms and is strong in many important areas of parallel software development. In fact, the large majority of the principal parallel software applications in use at EU HPC sites have been created and are further developed in Europe. However, the mastering of advanced HPC hardware is closely linked to the associated software and losing out on one side inevitably leads to a loss on the other.

[6] www.top500.org/charts/list/37/countries

4. TOWARDS A RENEWAL OF HPC IN EUROPE

The need for an EU-level policy is increasingly accepted

The development of HPC has long been a national affair for Member States, often driven by military and nuclear energy applications. In recent years the increasing importance of HPC for researchers and industry, as well as the exponential rise in the investments required to stay competitive at world level, have led to a common understanding that 'Europeanisation' of this domain would benefit everyone. This is also true for those Member States which encounter difficulties in creating self-sufficient national HPC infrastructures whereas they can make valuable contributions to and benefit from EU-level HPC capabilities.

In 2006 the "HPC in Europe Taskforce" published a White Paper entitled 'Scientific Case for Advanced Computing in Europe'[7] that argued the case for HPC to support EU competitiveness. This work was carried out in the context of the ESFRI[8] Roadmap for Research Infrastructures. It led to the consolidation of national HPC strategies, e.g. in Germany and France with the creation of the Gauss Centre for Supercomputing e.V. and of GENCI (Grand Equipement National de Calcul Intensif) respectively. In turn these developments resulted in the setting up of PRACE, as Member States and national actors have realised that only through a joint and coordinated effort will they be able to stay competitive. This was supported by the Council in 2009, which called for further efforts in this domain.

A Window of Opportunity is Opening Now

HPC is currently undergoing a major change as the next generation of computing systems ('exa-scale systems'[1]) is being developed for 2020. These new systems pose numerous hard challenges, from a 100-fold reduction of energy consumption[9] to the development of programming models for computers that host millions of computing elements. These challenges are the same for all actors in the field and cannot be met by mere extrapolation but require radical innovation in many computing technologies. This offers opportunities to industrial and academic players in the EU to reposition themselves in the field.

Europe has expertise across the full supply chain

Europe has all the technical capabilities and human skills needed to tackle the exa-scale challenge, i.e. to develop native capabilities that cover the whole technology spectrum from processor architectures to applications[10]. Even though the EU is currently weak compared to the US in terms of HPC system vendors, there are particular strengths in applications, low-power computing, systems and integration that can be leveraged to engage successfully in this global race, getting the EU back on the world scene as a leading-edge technology supplier.

---

7 www.hpcineuropetaskforce.eu/files/Scientific case for European HPC infrastructure HET.pdf

8 European Strategy Forum for Research Infrastructures ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

9 In line with Europe's green economy targets, ec.europa.eu/europe2020/targets/eu-targets/index_en.htm; COM(2009) 111, Mobilising Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy

10 HPC expert consultation meetings in September 2010 and March 2011 cordis.europa.eu/fp7/ict/e-infrastructure/events-p-2011_en.html

Partnership for Advanced Computing in Europe — PRACE is leading the way

Following the creation of the PRACE legal entity in 2010, the academic sector is pooling its leadership-class computing systems as a single infrastructure and makes them available to all researchers in the EU. Critical mass is achieved and access to these top-of-the-range HPC systems is provided on the basis of scientific excellence rather than the geographical location of a researcher. PRACE is further extending its services to mid-range HPC systems with the objective of providing a distributed computing platform that serves its users irrespective of their location and the availability of national resources. The PRACE model of pooling and sharing systems and expertise makes optimal use of the limited resources available.

The benefits for Europe of re-engaging in HPC

Gaining an independent access to HPC systems and services in the EU would support growth and competitiveness in the ICT industry and the economy in general. Investments in HPC centres of excellence would help to design and build dedicated HPC systems with specific features optimised for a given societal or industrial challenge (e.g. simulating the human brain needs a different computing architecture than designing and simulating a more efficient battery for electric cars).

5. THE CHALLENGES AHEAD

The confluence of the three factors discussed above, (i) the race towards exa-scale computing, (ii) the availability of technology supply in Europe and (iii) the success of PRACE, now makes it possible for the EU to re-engage in HPC and to strive for leadership both in the supply of technologies, systems, application codes and services, and in their use for solving major scientific, industrial and societal problems.

Reversing the current decline of HPC in the EU requires the pooling of efforts to more effectively address a number of shortcomings and challenges:

(a) There is still fragmentation of public HPC services across the EU and within Member States. This leads to inefficient use of resources and only partial exchange of expertise.

(b) The EU spends substantially less than other regions on acquiring high-end computing systems (only half compared to the US, at a similar level of GDP[5]). Consequently, the amount and performance of computing systems available in the EU are simply too low compared to other world regions, and R&D budgets devoted to HPC are small.

(c) Within the Union, only very few public procurement budgets are devoted to R&D through Pre-Commercial Procurement (PCP), in comparison to the US[11]. PCP is available as a means to procure innovative R&D for achieving specific technology and system targets. Especially in the US, PCP is used to advance the state-of-the-art

[11] COM(2007) 799, Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe: "The US public sector is spending $50Bn per year in procurement of R&D, an amount which is 20 times higher than in Europe"

of HPC[12]. Within the Union the majority of high-end HPC systems are procured by the public sector. Pooling national and EU resources for PCP is a key enabler to advance the EU's HPC capabilities and to develop the exa-scale HPC systems that no single Member State can afford.

(d) It is very difficult for European HPC vendors to sell their products to the public sector in non-EU countries that have national HPC vendors, due to national regulations e.g. for national security. At the same time, IPR developed in European research projects relevant to HPC often benefit mainly the non-EU parents of participating companies as the Framework Programme imposes few restrictions on the transfer of IPR to affiliates in third countries. Therefore, a more balanced arrangement needs to be found.

(e) The interaction between industry and academia on the exploitation of high-end computing systems, application codes and services is limited, especially regarding the use of HPC for industrial and service innovation. Europe also lacks advanced experimental high-end computation facilities that would allow industry and academia to explore exa-scale technology options or co-design hardware and software for specific applications.

(f) There is only a small workforce available that has the adequate educational background and is well trained in HPC especially in parallel programming. In addition, scientists that look after the computational tools and application codes often do not have an attractive career path. This hinders the exploitation of HPC in research and industry. By 2020 the computing power available in today's most performant HPC systems will be available on desktop systems. A well trained workforce capable of efficiently using this computing power is essential.

6. AN ACTION PLAN FOR EUROPEAN LEADERSHIP IN HPC

The Council asked for a further development of the European High Performance Computing Infrastructure and a pooling of national investments in HPC in order to strengthen the position of European industry and academia in the use, development and manufacturing of advanced computing products, services and technologies[3]. This is the high-level objective driving a renewed European HPC strategy.

Specific Objectives

To realise this general objective, the following specific objectives have been identified:

- Provide a world-class European HPC infrastructure, benefitting a broad range of academic and industry users, and especially SMEs, including a workforce well trained in HPC;

- Ensure independent access to HPC technologies, systems and services for the EU;

[12] EURAB report, PREST, 2004, US defence R&D spending: an analysis of the impacts

- Establish a pan-European HPC governance scheme to pool enlarged resources and increase efficiency including through the strategic use of joint and pre-commercial procurement;

- Ensure the EU's position as a global actor.

HPC is of high strategic importance for European society, competitiveness and innovation. To achieve the objective of excellence in HPC use and to ensure independent access to systems and services in the EU, several measures need to be put in place at the same time by Member States, the Commission and industry. These measures (listed below) will impact on both the supply and the demand of HPC, in a synergetic manner.

Complementary research activities specific to HPC are not directly addressed as such here because they will be part of advanced computing under the EU's Common Strategic Framework for Research and Innovation – Horizon 2020[13].

6.1. Governance at EU Level

An Action Plan for an EU HPC renewal requires adequate governance for setting concrete objectives, deciding policies, monitoring progress and efficiently pooling and using resources available across the Member States. Governance should be fair, open, simple and efficient, helping to balance and arbitrate on interests, capabilities and resources.

There are two main dimensions to such governance. They are linked to each other via the HPC/PRACE centres driving development and innovation.

(a) For industry, through the industry-led technology platform for EU HPC suppliers, and a network of competence centres providing expertise and services on HPC applications and software development;

(b) For science, through PRACE and centres of excellence addressing key societal and scientific challenges by deployment and application of HPC software and services;

- The EU Industry engaged in supply of HPC systems and services should coordinate research agendas through the technology platform and thereby create critical mass of industrial R&D in HPC.

6.2. Financial Envelope

The 2009 investment level of EUR 630 million per year[5] for acquiring high-end HPC resources across Europe is not sufficient to sustain HPC systems and services at a globally competitive level. It would need to double to some EUR 1.2 billion per year to bring Europe back as a major actor in the field of HPC[5]. Consultations with stakeholders have confirmed such an increased investment.

Supplementing the current efforts, an additional EUR 600 million would therefore be needed annually, to be shared between national budgets, the Commission (e.g. Joint Programming)

[13] COM(2011) 811 final, Specific Programme Implementing Horizon 2020 - The Framework Programme for Research and Innovation (2014-2020), 1.1. Information and Communication Technologies: Next generation computing.

and industrial users. Roughly half of these additional resources would be for the procurement of HPC systems and testbeds, a further quarter for training people, and the last quarter for development and up-scaling of HPC software.

- The Union, Member States and Industry should increase their investments in HPC to some EUR 1.2 billion per year – equal in terms of GDP to other world regions.

6.3. Pre-commercial Procurement Mechanisms and Pooling of Resources

The public sector is the major buyer of high-end HPC. Some of its budget (in the order of 10% per year) used for acquiring HPC systems in the EU should be used for PCP in order to develop and maintain native EU supply capabilities that cover the whole technology spectrum from processor architectures to applications. Via these government-initiated investments, support to HPC suppliers in the EU could be provided[14] for developing a leadership-class HPC system about every 2 years.

PCP actions for HPC R&D in the EU could become eligible for Union co-funding (e.g. via Horizon 2020 – e-Infrastructures; cohesion policy instruments)[15] by following one of the schemes given below:

(a) Joint PCP actions involving several or all Member States (e.g. organised through PRACE) for developing leadership-class HPC capabilities with a clear European mission.

(b) PCP actions carried out by large users or Member States individually (i.e. without pooling national budgets) could also receive funding[15] (to a lesser extent than in (a)) if (i) an appropriate share of the resulting HPC development is made available to all European users, (ii) the PCP is open to all legal entities entitled to receive financial contributions from Horizon 2020, and (iii) specifications are defined so that they reflect needs at EU level.

- Member States are invited to carry out joint procurement activities and to use PCP to stimulate the development of advanced HPC systems and services. Each Member State should actively encourage the use of PCP and devote in the order of 10% of its annual HPC procurement budget to it.
- The Commission should contribute to the funding provided collectively by Member States for PCP of R&D on HPC systems services with an EU-level mission and with EU-wide availability.
- HPC e-Infrastructure projects receiving funding from the Commission should be encouraged to use PCP where relevant.
- EU Industry is encouraged to actively engage in advanced HPC and application development efforts in response to PCP.

[14] In line with WTO Government Procurement Agreement, Article III

[15] Within the limits of the budget allocated in the programme for that purpose. Subject to the adoption of the Horizon 2020 Programme by the Legislative Authority.

6.4. Develop further the European HPC eco-system

PRACE ensures the wide availability of HPC resources on equal access terms. It has to be further strengthened to acquire the competence to (i) pool national and EU funds, (ii) set the specifications and carry out joint (pre-commercial) procurement for leadership-class systems, (iii) support Member States in their preparation of procurement exercises, (iv) provide research and innovation services to industry, and (v) provide a platform for the exchange of resources and contributions necessary for the operation of high-performance computing infrastructure.

Additionally, an e-Infrastructure for HPC application software and tools needs to be put in place. It should further consolidate the EU's strong position in HPC applications by coordinating and stimulating parallel software code development and scaling, and by ensuring the availability of quality HPC software to users.

- PRACE member countries should support the evolution of PRACE towards a globally leading e-Infrastructure.
- Centres of excellence should be established for the application of HPC in scientific or industrial domains that are most important for Europe (e.g. in the area of energy, life-sciences and climate).
- PRACE should refine its governance for the extended role described above; prepare for a first major PCP exercise in 2014; continue to make its services available to the entire European research and education community; and provide training and expertise to industry. Supercomputing centres, which represent their countries as the main PRACE partners, should strengthen and organise the PRACE legal entity in such a way that it is able to take on this expanded role.
- European Industry is strongly encouraged to make use of the services and know-how offered by PRACE and its partners.
- The Commission will continue to support PRACE and ensure it remains an integral part of the European e-Infrastructure; and it will provide support for establishing and operating a European e-Infrastructure for HPC.
- Hardware and software co-design centres should be established to focus on the advancement of technologies, HPC resources, tools and methodologies.

6.5. Industry Fully Exploiting HPC

Industry has a dual role in high-end computing: firstly, supplying systems, technologies and software services for HPC; and secondly, using HPC to innovate in products, processes and services. Both are important in making Europe more competitive. Especially for SMEs, access to HPC, modelling, simulation, product prototyping services and consulting is important to remain competitive. This Action Plan advocates for a dual approach: strengthening both the industrial demand and supply of HPC.

- Member States are encouraged to set up HPC competence centres that facilitate access of industry and specifically SMEs to HPC services, and should support supercomputing centres to transfer expertise to them.

- The Commission should support the establishment of a network of HPC competence centres to promote pan-European services and the dissemination of best practice (e.g. supporting HPC expert teams assisting industry users).

- Member States and the Commission should take the measures necessary to develop a much larger workforce that is well educated and trained in HPC (e.g. through a model curriculum; and through training at the HPC competence centres)[16].

- EU HPC Industry should strengthen its efforts to ensure an independent and state-of-the-art EU supply of key HPC components, software and systems.

- EU Industry should take a proactive attitude towards the use and application of HPC as an essential tool for the development of innovative services and products.

6.6. Ensuring a level playing field

To develop an autonomous and viable industrial capability in leadership-class HPC, the EU needs to ensure that its HPC industry has fair access to the worldwide markets in the same way that industry from other world regions has access to the EU's internal market; and that European R&D investments in the HPC field benefit clearly the EU economy.

- The Commission shall raise inequalities in HPC market access in its ICT Dialogues and trade negotiations with the countries concerned, with the aim of ensuring that their national HPC procurement and R&D are open to EU-based industry[14].

- For IPR that is generated in the area of HPC with Horizon 2020 support, the Commission may apply additional exploitation obligations[17].

7. CONCLUSIONS

With the setting up of the European Space Agency (ESA) in 1975, Europe decided that independent access to space was a strategic goal that was essential for Europe's competitiveness. This Communication advocates a similar strategic decision for HPC systems and services that are essential for the EU's social, economic and scientific development and its competitiveness. This renewed HPC strategy will position the EU as a centre of innovation, a hub of scientific excellence and a global partner. The EU should be among the leaders of the global race towards exa-scale computing.

The Commission, working closely with the Member States, will monitor the implementation of this Action Plan and will report to the European Parliament and Council by 2015.

---

16 In line with COM(2007) 496, e-skills for the 21st century: Fostering competitiveness, growth and jobs

17 In line with Articles 40 and 41 of COM(2011) 810 final, Rules for the participation and dissemination in 'Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)'