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Information Technology

High-Performance Computing and Networking

Report of the High-Performance Computing Applications Requirements Group

" HPCN enables us to improve the way we work"

April 1994

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EXECUTIVE SUMMARY

There is an increasingly critical dependence of industry in general on IT: for its products, in its products and in its business processes. The performance and cost/performance of high-performance computing and networking (HPCN) provides levels of functionality either not attainable or not economically viable using "conventional" technology and this offers European industry a host of new business opportunities

The High-Performance Computing Applications Requirements Group was established in late 1993 and is comprised of senior representatives of European industry in general with experience of the industrial application of HPCN, from systems embedded in products to enterprise-wide information systems.

At meetings held in late 1993 and early 1994, the group was asked to, from an IT user's perspective, recommend actions to be taken at Community level to ensure that European industry in general was able to exploit the business opportunities enabled by HPCN.

The group highlighted the importance of HPCN to European industry in general through a wide-ranging set of exemplars of existing and potential HPCN applications. The group believes that R&D activities have produced a core of HPCN technology that is ready for exploitation by industry in general. However, the group identified a number of barriers and issues affecting the widespread use of HPCN in industry in general and recommended a number of actions that should be taken at Community level.

The group emphasised that networking is vital to HPCN applications, and reciprocally that HPCN is vital to the operation and use of the "information infrastructure". However, with knowledge of and some overlap in membership with the 'High-Performance Networking Requirements Group', they deferred specific recommendations relating to networking to that group.

The group recommends that, in the context of the Specific Programme on IT of the 4th Framework Programme for Community R&D:

(1) the Commission support an HPCN awareness and promotion campaign to establish a clear understanding of the role, contribution and deployment of HPCN in industry in general: centred on "showcase demonstrator" applications;

(2) the Commission support an HPCN technology transfer and training programme for applications developers to build a corpus of expertise and best practice in the application of HPCN: centred on "applications experiments";

(3) the Commission support an HPCN technology R&D programme to complete the underlying HPCN technology base: centred on "prototype applications";

(4) projects be based on a vertical triumvirate of: (i) user; (ii) application developer; and (iii) technology supplier(s).

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1 INTRODUCTION

There is an increasingly critical dependence of industry in general on IT: for its products, in its products and in its business processes. The performance and cost/performance of high-performance computing and networking (HPCN) provides levels of functionality either not attainable or not economically viable using "conventional" technology and this offers European industry a host of new business opportunities

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The remainder of this report is divided into two parts: the first presents the need for action highlighted by the group; and the second presents the group's recommendations.

The appendix outlines the possible themes for the HPCN technology R&D programme suggested by the group.

2 THE NEED FOR ACTION

2.1 The Importance of HPCN to European Industry

2.1.1 Defining HPCN

The group worked with a broad definition of HPCN, covering a large and diverse area ranging from embedded systems to client-server architectures.

An attribute common to all the HPCN applications presented by the group is that **HPCN provides levels of functionality either not attainable or not economically viable (i.e. with an acceptable cost/performance ratio) using "conventional" technology**. Another common attribute is that HPCN systems are scalable. These attributes can be identified in workstation clusters and client-server architectures, as well as the more obvious example of massively parallel processors.

2.1.2 HPCN Applications

The group believes that **HPCN has a role to play in all business activities** and that **HPCN offers a host of new business opportunities**.

The group presented a wide-ranging set of exemplars of existing and potential HPCN applications, these are outlined below.

(1) **HPCN for products** (i.e. design, simulation and manufacture): e.g. aerodynamic design; crash testing; drug design/discovery; design of chemical reactions and catalysts; materials design; metal forming; forging; casting; injection moulding; lens production; VLSI circuit simulation; electricity supply systems; seismic modelling; oil reservoir modelling; behaviour of degenerate systems; new product opportunities identified using "data-mining"; ...

(2) **HPCN in products** (i.e. embedded systems): e.g. simulation-in-the-loop control systems (e.g. planes, cars, etc.); medical imaging systems; interactive home entertainment; moving off-line back office customer-oriented services to real-time front office services (e.g. banks, etc.); ...

(3) **HPCN in business processes** (i.e. information management and decision support): e.g. the provision of financial and management information; credit ratings; risk assessment; market research; targeted advertising or direct selling; fraud detection; planning and scheduling; logistics; workflow management; "virtual corporations"; ...

The group noted that networking is vital to HPCN applications. In general, HCPN applications are either themselves (heterogeneous) networks of components or are integrated into networks to form part of the overall (product/enterprise/societal) IT infrastructure. This places emphasis on the design, management and operation of heterogeneous network systems.

The group noted that information management is equally as important for scientific/engineering applications as it is for commercial application. It was projected that, in line with traditional IT applications, more than half of future HPCN applications will be concerned with information management.

The group sees three classes of applications:

(1) doing what is done today but faster and/or cheaper or on larger volumes of data;

(2) doing what is conceivable today but not technologically/economically possible;

(3) totally new applications: which by definition cannot be elaborated here, but are envisaged to be complex, business-process-related applications combining high-performance computing, high-volume data handling and high-performance networking.

The group noted that class (2), 'doing what is conceivable today but not technologically/economically possible', would be of particular importance over the next three to five years. The new economics of HPCN would allow its use to be moved "down market": either to applications where HPCN was previously precluded by cost; or to enterprises, particularly SMEs, which could not make the scale of investment previously required. The group felt that PC- or workstation-clusters would play a major role.

2.1.3 HPCN Benefits

The group highlighted the potential benefits of HPCN to European industry in general through the applications exemplars presented, an illustrative collection of which is given below.

The group insisted that the application of HPCN should be viewed as an investment with an expected return rather than an overhead expenditure.

The most obvious and easiest to measure business **benefits of HPCN are the actual savings that can be achieved on current operations** by the application of HPCN.

Example: It is projected that the use of HPCN crash simulation to replace physical experiments could reduce both the cost and time of a car safety programme by 30%; in 1992 the European automotive industry spent 150M ECU in this area.

Example: A European lens manufacturer is using HPCN modelling to optimise the thermo-forming of glass blanks, a process that was previously done by "trial and error" empirical adjustments on prototypes. HPCN will allow them to reduce the time to market for progressive addition lenses from 24 months to only 5.

More difficult to measure, but probably of greater payback, is **HPCN as an enabling technology for new business processes**.

Example: An automobile manufacturer is using HPCN to decide where to locate its dealers in a European country. With several hundred dealers it is impossible to perform any optimisation, stricto sensu, but an HPCN decision support system has made it possible to find solutions which are expected to improve revenues by around 10%.

Example: The monthly balance sheet of a major European bank operating in 50 countries world-wide previously required 30 people working for 30 days to prepare. An HPCN information management system now permits it to be produced in one day. In addition to the savings in labour costs, the system permits the previously impossible management information and the execution of previously intractable "what-if" queries.

Example: A large credit card company is using an HPCN information management system to "mine" its card holder database (where all the transactions are recorded) to discover and target new marketing and product opportunities. HPCN allows queries that take 5 days on a large conventional system to be executed in 2 hours.

Finally, there are the less quantifiable but nevertheless **important secondary benefits of using HPCN**.

Example: HPCN is being used by the European pharmaceutical companies to improve drug design and discovery techniques. Traditionally these involve many "trial and error" experiments. HPCN enables the behaviour of compounds to be predicted through computer modelling, which leads to more directed experimentation and less "errors". It is projected that HPCN may reduce the typical ten-year to-market period by two or more years. A major secondary benefit is a reduction in the amount of animal or human testing, with its unquantifiable, but increasingly significant in the European market, benefits as far as consumer image are concerned.

2.2 Barriers and Issues Affecting the Widespread Use of HPCN

2.2.1 Lack of Awareness of HPCN

The group believes that there is **a lack of awareness in industry in general of the widespread business opportunities enabled by HPCN**.

There was thought to be a particular lack at the level of managers and strategists, who frequently lack the appropriate background information for "business case" decision making relating to investments in HPCN applications, e.g. technological capabilities, costs, risks, etc. This is believed to result from both a genuine lack of quantitative information and insufficient dissemination of what information there is available.

Also, industry in general must be made aware: that the new levels of functionality provided by HPCN enable it to undertake tasks (in ways) that were not previously possible (viable); and that the new levels of cost/performance enable SMEs to employ techniques and processes that were previously only available to major enterprises.

2.2.2 Insufficient Expertise in and Experience of HPCN

The group believed that, in general, **the major developers and integrators of software (typically the applications vendors and the software houses) have insufficient expertise in and experience of HPCN** to support its widespread use in industry in general.

The group pointed out that much of industry's software was, and is increasingly, developed by third-parties. At present, HPCN applications must generally be developed in-house. Not only is this against the trend, but it also increases the HPCN adoption costs, as additional, HPCN competent, staff must be hired. The group believed that many potential users of HPCN had been deterred from doing so by not being able to procure the applications from their traditional suppliers.

2.2.3 Changes to Problem Solving Techniques and Business Processes

This is **a largely positive issue**: the levels of functionality and cost/performance offered by HPCN enables industry to solve problems (or use techniques) that were not previously tractable (viable) and to implement business processes not previously possible. HPCN is an enabling technology for much of the "business process re-engineering" currently being undertaken.

2.2.4 Gaps in the Underlying HPCN Technology Base

R&D activities have produced a core HPCN technology which is capable of exploitation by European industry in general. However, when considering the requirements of the HPCN applications they presented, the group pinpointed a number of gaps in the underlying HPCN technology base where specific **R&D is still needed**. These are at both the applications and the systems and software levels and are outlined in Appendix I.

3 RECOMMENDATIONS

The group believes that R&D activities have produced a core of HPCN technology that is ready for exploitation by industry in general. However, the group believes that **Community level action, primarily concerned with accelerating and widening the take-up of HPCN, is required to ensure that European industry in general is able to exploit the business opportunities enabled by HPCN** by addressing the barriers and issues that the group identified.

In general, HCPN applications are either themselves (heterogeneous) networks of components or are integrated into networks to form part of the overall (product/enterprise/societal) IT infrastructure. Networking is therefore vital to HPCN applications. The group emphasised this, but with knowledge of and some overlap in membership of the 'High-Performance Networking Requirements Group', they deferred specific recommendations relating to networking to that group.

Research on "innovation diffusion" has identified a number of major factors, both technological and economic, that influence the adoption of new technology: relative advantage; complexity; observability; triability; compatibility; prior technology drag; and sponsorship.

In the light of their experiences and the above factors, the group recommended three specific major lines of action and made a number of general recommendations.

3.1 An HPCN Awareness & Promotion Campaign

The group recommended that **the Commission should support an HPCN awareness and promotion campaign** to establish a clear understanding of the role, contribution and deployment of HPCN in industry in general.

Primary targets would be managers and strategists, to provide them with the appropriate background information for "business case" decision making relating to investments in HPCN applications: e.g. capabilities, costs, risks, etc. The emphasis should be on demonstrating the return on investment for HPCN.

The group considered that "the proof of the pudding was in the eating" and recommended that integral to and at the core of the campaign should be the development of "showcase demonstrators": applications whose primary aim, from a Community perspective, is to quantitatively demonstrate the capabilities, costs and benefits of HPCN.

A showcase demonstrator should typically be an operational system, therefore one which may be specific to a particular business or application area, but one from which information of a generic nature can be abstracted. Specific information dissemination and training activities should be associated with all showcase demonstrators. The emphasis should be on meeting targets, proving the scalability (up and down in size), satisfying business related requirements such as integrity and demonstrating the HPCN's impact on industry.

The campaign should include information dissemination and training actions (e.g. conferences, seminars, briefings, etc.) and support material (e.g. CD-Is, videos, books, brochures, articles in the appropriate general press and specialist publications, etc.). These

parts of the campaign should be undertaken by professional communications and training companies/consultancies.

Actions and materials could be general or industry- or country-specific.

A "yellow pages" of information and services might also be established as part of the campaign.

Industry organisations should play a role, particularly with respect to SMEs.

It must be ensured that the campaign generates realistic expectations.

3.2 An HPCN Technology Transfer and Training Programme

The group recommended that **the Commission should support an HPCN technology transfer and training programme for applications developers**, to build a corpus of expertise and best practice in the application of HPCN.

The group suggested that the programme should primarily aimed at industrial applications developers. Applications vendors, software houses and consultancies ensure the maximum leverage/multiplying-effect.

An applications experiment should typically be an (or a scaled version of an) operational system, therefore one which may be specific to a particular business or application area, but one from whose development skills of a generic nature can be abstracted. Specific training activities should be associated with all applications experiments. The emphasis should be on building expertise and experience of technologies, tools, techniques and best practices in applications developers.

The group considered that "real-world experience" was essential and recommended that integral to and at the core of the programme should be the development of "applications experiments": applications whose primary aim, from a Community perspective, is to provide applications developers with "hands-on" training in HPCN technologies, techniques and best practices.

The programme should address systems analysis and design as much as programming.

The programme should consist of specialised actions and support material (e.g. CD-Is, videos, books, etc.).

The group also suggested that HPCN should be included in graduate and post-graduate education: in the courses of potential users, as well as in computer science courses.

3.3 An HPCN Technology R&D Programme

The group recommended that **the Commission should support an HPCN technology R&D programme to complete the underlying HPCN technology base**.

The group felt that technological R&D should be strongly related to its application and recommended that R&D projects should take the form of "prototype applications": applications whose primary aim, from a Community perspective, is to establish the user requirements on and prototype the application of the technology.

Prototype applications are expected to involve not just technology suppliers but also users and applications developers to establish the requirements on and prototype the use of technologies. A prototype application should place emphasis on expanding the applications potential of HPCN by extending the underlying technology.

On the basis of the requirements arising from existing or potential HPCN applications in their industrial sectors, the group suggested a number of broad themes for the R&D programme. These are outlined in Appendix I and will be used as input to the definition of the workplan of the HPCN action line of the Specific Programme on IT of the 4th Framework Programme for Community R&D.

3.4 General Recommendations

3.4.1 Participation

The group thought that it was important to **involve as broad a range of European industry as possible**: particularly in the HPCN awareness and promotion campaign, as HPCN, in particular the cost/performance of HPCN, offers opportunities for some problem solving techniques and business processes to be used in industries where it was not previously possible.

3.4.2 Scale of Activity

The group estimated that the scale of activity required is **approximately 1000 people working on around 50 applications** projects over a period of three years.

3.4.3 Applications Projects

The group recommended that **applications projects be based on a vertical triumvirate of: (i) user; (ii) application developer; and (iii) technology supplier(s)**.

In considering applications project proposals, it is important for projects to be clearly placed within one of the three categories (showcase demonstrators, applications experiments and prototype applications), in order to avoid unwarranted expectations and the subsequent associated disappointment.

It is vital for applications projects to be realistic and provide a convincing demonstration, particularly showcase demonstrators. This means that the timescales and targets should be meaningful in an industrial context (to users, managers and strategists), since "horror stories" of massive slips or undelivered functionality will have a major detrimental effect.

3.4.4 HPCN "Centres of Competence"

The group recommended that **HPCN "centres of competence" should be established**. The group proposed three roles for such centres:

(1) to support technology transfer and training for HPCN applications developers;

(2) to provide facilities for industrial users to conduct trials with HPCN;

(3) to provide access to HPCN for small and medium-sized enterprises (SMEs).

3.4.5 Community Support

Whilst the group did not discuss support mechanisms in detail, it did suggest that the current Commission rule of providing 50% of project costs may not be appropriate in all cases. For example: organisations undertaking information dissemination actions should perhaps be 100% funded; whilst the user organisation in a showcase demonstrator, for whom an operational system is developed, might perhaps receive only limited funding. The group recommended that **the Commission should investigate more flexible support mechanisms**.

The group suggested that in the case of applications development projects, the funds might be allocated to the user, who would then be responsible for "procuring" the applications development and technology supply.

Although the actions suggested fall largely with the 'HPCN' action line of the Specific Programme on IT of the 4th Framework Programme for Community R&D, some projects related to the use of HPCN in business processes might draw from the 'Technologies for Business Processes' action line of the IT programme.

APPENDIX

I SUGGESTED HPCN TECHNOLOGY R&D THEMES

Listed below (without any order of priority) are the HPCN technology R&D themes suggested by the members of the group.

- **Migration Aids**

  Techniques and tools for moving existing applications onto HPCN systems are a priority.

  Related to this, but at another level, PC or workstation-clusters which permit the reuse of the installed hardware base are important migration aids (as well as cost-effective HPCN platforms in their own right), making improvements in such systems important.

- **New Problem Solving Techniques and Business Processes**

  On the one hand, HPCN enables either previously unviable or new algorithms to be used, on the other hand, some existing algorithms are unsuitable for HPCN systems and new ones have to be discovered.

- **Applications Development and Maintenance Tools**

  HPCN software development environments, and in particular HPCN "applications generators", are important for widening the take-up of HPCN.

  Tools for functional testing and debugging are a priority.

  Of particular priority are performance analysis and tuning tools. Also of importance are performance and scalability modelling tools.

- **Design and Operation of Heterogeneous Systems**

  In general, HCPN applications are either themselves (heterogeneous) networks of components or are integrated into networks to form part of the overall (product/enterprise/societal) IT infrastructure. This places emphasis on the design, management and operation of heterogeneous network systems.

  Important issues are data sharing/exchange and more generally interoperability/interworking.

- **Information Management Systems**

  The developments needed here are not replacements for the well established database systems but rather technologies that add value to these systems, both "below" to allow HPCN systems to be used effectively and "above" to support advanced information management and decision support techniques (e.g. "data-mining").

  Support for complex data-types (e.g. multi-media) is a priority.

  Developments at the level of storage technology (i.e. increases in data access and transfer rates and increases in the storage/volume ratio - "a tera byte in a cabinet" was given as a target) are necessary.

- **Visualisation**

  Visualisation is a key component of many HPCN applications, simulation and information management in particular. Tools to facilitate the use of visualisation are a priority.

  Also, advances in the performance and cost/performance of the underlying technologies (both hardware and software) are necessary.

- **Integrity, Fault-tolerance, Archiving, etc.** (at both the hardware and software levels)

  The provision of "systems management" technologies and tools comparable in "sophistication" to those available for "conventional" systems is a priority.

- **High-performance Input and Output** (including network connections)

  In addition to throughput, a priority is the support of complex data types, e.g. multi-media.

- **Standards**

  The group agreed that standards have a role to play in widening the take-up of HPCN. However, many members of the group questioned whether HPCN technology and practice was mature enough to permit significant action at the current time.

  Data and information exchange was seen as a first priority, to facilitate the interworking of HPCN and "legacy" systems and more generally for the development of heterogeneous systems.

  Standard programming paradigms and languages were considered to be important. However, it was felt that the promotion of "best practices" was more important.