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OCDE/GD(94)105

COMMITTEE FOR INFORMATION, COMPUTER AND COMMUNICATIONS POLICY

NATIONAL R&D PROGRAMMES FOR NEW COMPUTER-COMMUNICATIONS NETWORKS AND APPLICATIONS

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1994

Foreword

Within the 1992/93 Programme of Work, the Committee for ICCP investigated development trends in advanced computing and communication networks and applications in the three OECD regions: Europe, North America and the Pacific. Particular emphasis was placed on public policies and related initiatives for high performance computing and communication (HPCC) networks and their applications.

This report presents the findings of the site visits and surveys major national R&D programmes for developing advanced computer-communication networks and applications. It provides a comparative analysis of the state of the art and emerging trends in HPCC in the countries concerned, reflecting the situation as at the end of 1993.

In addition, the report proposes a number of recommendations and presents a refined list of research questions for a more continuous monitoring of developments in HPCC and its driving forces.

The Group of Experts on Economic Implications of Information Technologies and the Committee for Information, Computer and Communications Policy discussed the report at their respective meetings on 18-19 October and 20-22 October 1993 and recommended its derestriction. The Committee will consider the question of updating and extending the work covered by this report in 1995.

Table of Contents

Page

Page

NATIONAL R&D PROGRAMMES FOR NEW COMPUTER-COMMUNICATION NETWORKS AND APPLICATIONS

PART I: EXECUTIVE SUMMARY AND FINDINGS

Chapter 1: Project Objectives and Study Conduct

1.1 Project context

This project is a direct follow-up of recent ICCP work on Information Technology (IT) networking (published in ICCP No 30: *Information Networks and New Technology*). In order to carry this work further, the ICCP Committee suggested examining the evolution of major national R&D activities on advanced computing and communications systems and networks, often referred to as high performance computing-communications (HPCC) networks. This area comprises advanced high-speed computers, switched data communications, distributed information and data bases, and related new technologies which support these systems and their applications. The Committee endorsed the proposal to carry this work out within the 1992/93 work programme under the title National R&D Programmes for New Computer and Communication Networks and Applications.

High performance computer-communication network issues rank high on the policy agenda of numerous Member countries. Several national governments are undertaking experiments with high performance computing and communication systems. These HPCC test-beds are designed with the view to identify emerging demand for new applications and new technological requirements which may affect IT demand (hardware and software segments) and trigger economic and social impacts. Likely organisational change, integration and other examples of restructuring activities due to the emerging technological and functional interconnections are fully integrated in the test-bed design. In focusing on emerging and likely applications, these projects aim at investigating the basic user/IT-development relationship within the changing socio-economic context and are not limited to the needs of particular IT interest groups, including telecommunications operators and IT manufacturers.

These experiments, if successful and if done in ways that will support eventual interconnection of the testbed islands, are likely to serve as the prototypes for, or forerunners of, a global high performance computing and communications infrastructure (information highways).

OECD's Committee for Information, Computers and Communication Policy (ICCP), in co-operation with the US National Science Foundation (NSF), Japan's Ministries for International Trade and Industry (MITI) and Posts and Telecommunications (MPT), and the Commission of the European Community, undertook the preliminary phase of a multinational research programme surveying and analysing these experiments.

1.2 Policy relevance of HPCC for OECD Countries

High performance computer and communication networks are not in the realm of science fiction. Experimental networks are in operation today and usage is expanding rapidly in many OECD countries and central Eastern European areas. While these activities are initiated as new infrastructure for research and education, they promise to provide at the same time fertile ground for innovation for the rest of the economy, resulting in new applications, creation of new demand, new enterprises, new employment opportunities, and public-private participation modes.

Insight into these emerging developments is important for all countries with or without domestic research and/or production capabilities in the HPCC area.

Surveying HPCC developments is of use to Member countries in several ways:

-- each experiment is based on a set of technological, social and economic assumptions and objectives. Better understanding of these assumptions and the economic and social intentions of other national programmes may help national governments plan their own programmes, and help show how they relate to similar research elsewhere;

-- for national governments that are not now involved in these experiments, a clearer picture of how the global high speed information infrastructure is evolving will help them anticipate and plan for their own future roles as well as articulate their own concerns and needs in international fora, including the OECD; and

-- these national experiments can be important laboratories for learning more about the economic, social, and policy dimensions of high-speed data communication. The OECD can play a key role in identifying and compiling valuable data and analyses gained from these experiments.

1.3 Study conduct and sites visited

With this perspective, the project involved the evaluation of major R&D programmes for HPCC networks and meetings at real-world sites of new HPCC applications in applied research, industry and education in Japan, the United States and Europe. The study was conducted by the Secretariat supported by an interdisciplinary research team of 12 experts nominated by Member countries. Their names are listed in the Annex. The research team had interviews in the order indicated at the following application sites:

Japan:	--	Meetings with senior officials of MITI and MPT, Tokyo;
(July 1992)	--	NTT Labs, Yokosuka;
	--	Institute for Computational Fluid Dynamics (ICFD), Tokyo;
	--	Electro-Technical Lab., Tsukuba;
	--	National Centre for Science Information System (NACSIS), Tokyo.
United States:	--	Bell Labs., Network Division, Murray Hill, N.J.;
(October 1992)	--	Bellcore, Broadband Services Branch, Morristown, N.J.;
	--	Cornell Theory Centre, Cornell University, Ithaca, N.Y.
Europe:	--	BERKOM, Berlin;
(November 1992)	--	TUBKOM, Technical University Berlin;
	--	RUS, Computer Centre of the University of Stuttgart;
	--	ICA, Institute for Computer Applications, University of Stuttgart;
	--	CERN, European Laboratory for Particle Physics, Geneva.

Chapter 2: HPCC: What Is It and Why Is It Needed?

2.1 Information: a strategic resource in the new economic context

OECD countries today are in a different situation from that in which most current computer and communications equipment was developed and deployed.

Production and consumption patterns are changing; just-in-time techniques on the supply and demand sides, and the trend towards customisation in all areas, are examples of these developments. International competition is growing and further product/service diversification is required. Furthermore, new public and social demands are rising, centering in particular around environmental and urban concerns, the quality of life, pollution and traffic congestion, both in air and ground transportation, and emerging trends in the demographic composition of the population, such as ageing.

Such changes lead to greater requirements for all economic agents to develop enhanced intelligence for research, production and distribution of goods and services. This new economic situation demands the use of information as a critical resource by all organisations, by both public and private sectors, and by individuals as well.

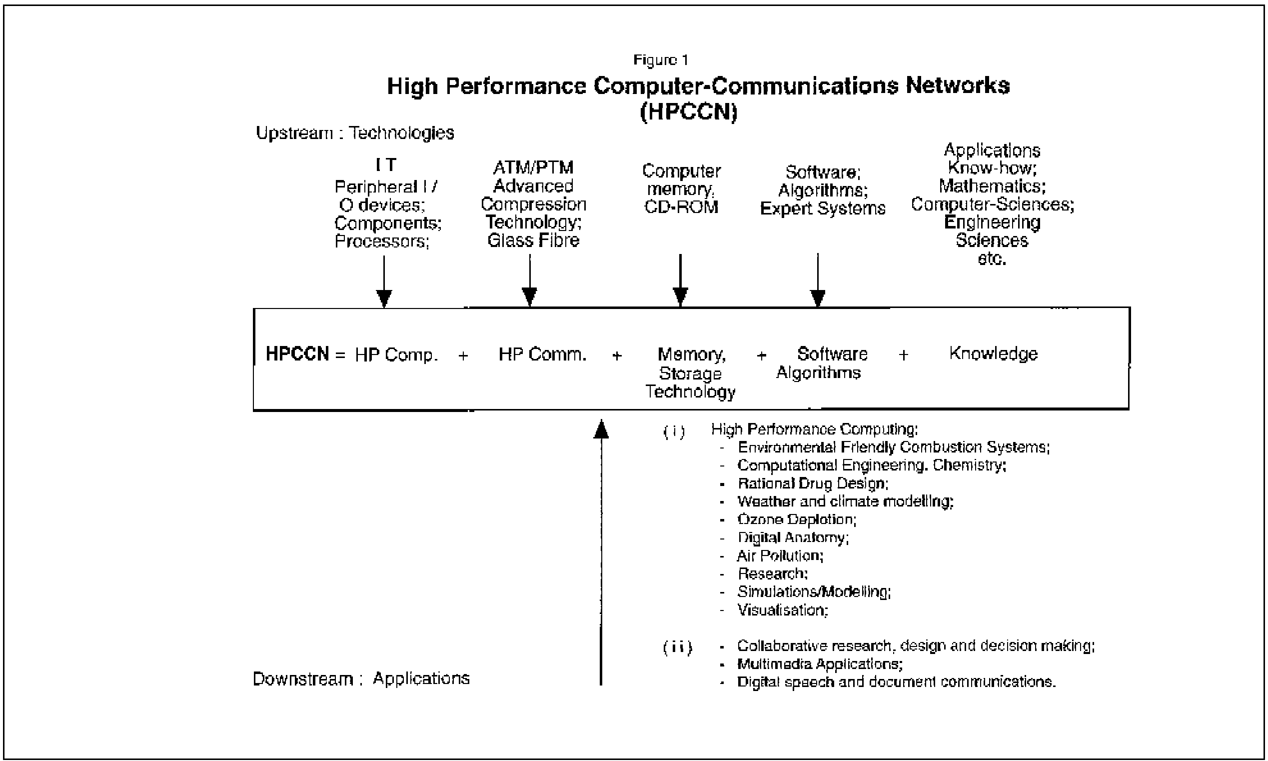
Coping with these developments and their information processing requirements puts new demand on information technologies (IT) as enabling tools to meet immediate needs and for developing more innovative solutions for a wide range of economic, industrial, scientific and social activities. These new applications, then, are driving the development of more powerful, faster and more user friendly computing techniques and enhanced interconnections via "switched" communication networks. These are often referred to as high performance computing and communication (HPCC) networks. Recent technological developments in the system components, in particular high speed computing, communications and switching promise major quantitative and qualitative advances in IT. Asynchronous transfer mode (ATM) technology and fibre optic transmission systems promise to solve technically old problems and make new applications economically viable.

Accordingly, the HPCC concept goes beyond the traditional core mainframe computer products and supercomputers. In this report, HPCC networks are defined as systems comprising:

- high performance processors with very fast interconnections;
- new software and algorithms for exploiting their potential;
- interfaces and peripheral equipment (e.g. workstations, systems for storage and running of simulations and their visualisation);
- high speed communication networks which allow:
    - efficient interworking of the system components;
    - remote access to these systems;
    - interaction between HPCC and data banks;
    - collaboration between geographically dispersed researchers;
- the availability of highly-trained human resources to work and develop innovative applications.

The term HPCC is used in a general sense in this report to reflect aspects of the above definition.

The available evidence (**Figure 1**) indicates a strong correlation between applications and new information technologies: the requirements of emerging applications are driving the development of new IT, e.g. input, and IT-based network configurations. The latter point is of utmost importance given the large number of components and players contributing to advanced information networks. Applications, then, determine the corridor within which IT segments develop and thus avoid pushing and pulling in different directions. Advanced applications are also maximising the chances of getting agreement on acceptable network configurations.



In contrast to currently marketed large-scale mainframe-based systems, the emerging HPCC system generation is built on the principle of massive parallel computing involving literally thousands of processors working simultaneously to process huge amounts of information under real time conditions. Future computer networks are designed to operate at gigabit speeds[1] which is an increase in performance of 1 000 over today's configurations.[2]

2.2 HPCC applications and their enabling economic potential

Factors driving high performance computing and networking include the pressure for decreasing costs and the search of innovative solutions. To better meet these objectives, advanced visualisation and dynamic simulation techniques are increasingly added to computing. This shift from the predominantly text and numbers based environment to the adding of images -- high quality colour pictures, video communications, advanced visualisation techniques (multidimensional imaging of a product or a problem) -- and multimedia communications (sound, graphical material, data) -- has dramatically increased the requirements for processing, storing and transmitting information. Another driving force comes from the experience with distributed computing in high performance local area networks (LANs) and the growing numbers of users that demand similar facilities provided across wide area networks (WANs).

The following examples may help to provide some insight into the vastly greater data volumes and transmission speeds that will be associated with image based networking:

- -- A five page journal in plain text is about 0.2 Mbits of data whereas the image of a five page journal scanned at 300 dpi (Digital Pixel Imagery) is about 35 Mbits;

- -- The storage requirements for a single colour image range from 2 Mbits for NTSC quality to 96 Mbits for a high quality image;

- -- Transmission rates for moving images range from 1.5 Mbits/sec. for compressed (Video Cassette Recorder) VCR quality to 1-4 gigabits/sec. for High-Definition TV (HDTV) quality with no compression.

Visualisation, simulation, and collaborative research in real time to better solve scientific and industrial problems require even greater data handling and transmission capabilities.

New HPCC-based applications, in addition, imply a mixing of styles in communication that are incompatible with traditional communication techniques and networks, namely the requirement in some applications for a steady, synchronised flow of data, traditionally supported on circuit-switched networks. In other cases there is a requirement to support a bursty, asynchronous flow of data more efficiently carried on a packet switched network.

With regard to applications of HPCC, the specialised literature provides an open-ended listing. The Rubbia Report and the US HPCC Programme identify four broad classes of HPCC applications, each illustrated by typical examples:[3]

- -- simulation and collaboration in scientific research and engineering;
- -- embedded systems applications;
- -- information management;
- -- grand challenges.

The site visits in the USA, Japan and Europe would suggest eventually adding a fifth category of applications:

- -- new entertainment services delivered to the home (digital HDTV).

These application classes evidently should not be considered as independent. In fact, they are mutually interdependent in adding up to the critical mass needed to bring costs down (economies of scale and scope) and thus encourage and strengthen the argument for developing national and international interconnected HPCC infrastructures.

Simulation and collaboration in scientific research and engineering

In the application to simulations, that is the abstraction and detailed reproduction of real world situations through mathematical representation and modelling, HPCC offers the integrated power of:

- -- dynamic prototype modelling;
- -- explanation;
- -- optimisation.

HPCC can provide insight into complex scientific and engineering problems, economic and social systems and processes much as telescopes and microscopes are used to make new discoveries and spur innovations. Conventional scientific and industrial R&D and design processes are hence revolutionised as they reduce time consuming and costly experimentation with prototype solutions. In fact, HPCC in the form of supercomputers in some industries (automobile, aviation, pharmaceutical, etc.) has already proven its viability in dramatically reducing R&D time and costs, hence improving competitiveness and the safety of products (e.g. car-crash tests).

Embedded systems applications

As HPCC tools become more affordable, it becomes feasible and economically viable to incorporate very high performance computing functions in other products and services. In this embedded form, the user has little or no direct access to computing elements, and is mainly concerned with their exploitation for pre-programmed tasks. Embedded HPCC has a wide range of applications: letter sorting, medical imaging, computer vision and automatic control, etc. In letter sorting, according to the Rubbia Report, automatic reading and understanding of addresses on mail is a highly computationally intensive task. To yield economies, throughput must be very high (45 000 items and more must be processed). Current address interpretation needs only 10-20 bytes per item, but recognition of, say, a scanned colour image starts at about 6 Mbytes. To increase the current recognition rate of approximately 80 per cent would require a massive increase in computer power.

Another concrete HPCC application is being introduced into the car market to assist in the prevention of theft and to locate stolen vehicles. Cars can be equipped with a processor to send signals at regular intervals to satellites. A pair of signals is required to locate the objective. A MP processor linked to a mobile telephone provides the large processing capacity needed to map the location, or the route of the stolen car, and can relay this information to authorities. Standard equipment of this type has a current cost of some US$ 1 200. This type of HPCC application is also increasingly used in transport logistics to optimise vehicle-fleet management and track the location of transported goods. Given the emerging changes in production (customisation, just-in-time, etc.), these new IT-based systems have significant implications for the economy; they enhance productivity in this crisis sector and generate significant social benefits through improving traffic flow and reduction of pollution as more optimal routing reduces traffic congestions and transport frequency, hence less consumption of fossil energy and increased safety.

Other examples of HPCC usage that are of great economic and industrial importance include:

-- signal processing in air traffic radar systems and HDTV;
-- image processing (e.g., medical, industrial and seismic images).[4]

Information management

A crucial ingredient for research, and innovation in general, is the use of HPCC tools in the management of information. Intelligent data base management and search procedures vital for a wide range of activities put new demands on computing power and distribution capacities. Information management is particularly critical in activities such as the following:

-- scientific research;
-- remote sensing;
-- marketing and financial programming;
-- system design;
-- consulting;
-- learning;
-- modelling (e.g. economic modelling, resource models, environmental models, alternative dimension evaluation);
-- planning; and
-- medical observation and diagnostic referral.

The international organisation of much economic and social activity also presents a challenge to the management of information that is being met by the development of HPCC infrastructures.

Grand challenges

To provide for the evolution of the HPCC network infrastructure, a number of grand challenge applications have been identified and targeted in the US programme. A grand challenge in this context is defined as a fundamental problem in science and engineering, with broad economic and scientific impact, whose solution could be advanced by applying HPCC techniques and resources.

To illustrate the diversity and significance of HPCC applications and hence underline the urgency of developing an appropriate HPCC infrastructure, the US initiative targets grand challenges such as those listed below:

- magnetic information storage technology;
- rational drug design;
- high speed civil transport;
- catalysis;
- fuel combustion;
- ocean modelling;
- ozone depletion;
- digital anatomy;
- air pollution;
- design of protein structures;
- imaging of the planet Venus;
- technology links from research to education.

The information processing needs of these applications will require continuous advances in computational power, improvements in computational models, communications and selected technologies. They are expected to exert leverage on the development of IT systems and related tools including: software tools, system software, higher languages, advanced competitive technology, inter-operability support and data management.

2.3 The strategic role of HPCC

HPCC is predicted to provide a new infrastructure upon which, and through which, most functions of modern economies will operate. HPCC networks, then, can be the new interphase between industry and technology with wide-spread ramifications for economic and social development.

As a tool to support conceptual, lateral thinking and investigations in a wide range of industrial, social, scientific and administrative tasks, HPCC is expected to show the most dramatic effects. In the US industrial sector alone, annual gains in productivity ranging from 1-3 percentage points are forecast to result from HPCCN.[5] A study conducted for the Commission of the European Committees (DG XIII) in 1993 yielded similar results. Based on a systematic sectoral analysis of the more industrially developed regions, sophisticated information systems are predicted to increase performance by 4-6 per cent over the next 15 years, if stimulation for both infrastructure implementation and usage innovations is provided.

HPCC applications are developed, tested and exploited first in research and diffused from there to industry. As yet, the applications adopted by industry are primitive compared with the potential that HPCC offers. However, these developments are application driven and target emerging demand. Consequently, leverage on IT developments in the IT manufacturing and related industries will be especially direct. HPCC activities therefore are expected to enhance the performance of the major hardware and software IT segments, including higher level languages, advanced computer technology, optimisation and parallelisation tools, inter-operability support and other tools.[6]

Again, **Figure 2** attempts to illustrate some of the likely upstream and downstream impacts of HPCC systems and their economic knock-on effects.

2.4 Economic and technological constraints

The development and implementation of HPCC networks involves the collaboration of many organisations in the private and public sectors. In addition, HPCC end-to-end networks are expected to require major changes in existing network technologies, usage and pricing patterns. Taken together, their implementation raises numerous economic and technological issues:[7]

-- the transmission and switching speed will exceed the limits of most current supercomputers and workstations. Available operating systems, protocols, software are unable to handle such capacities without radical changes;

-- a major technical and economic challenge is presented by the flexible customised bandwidth requirements of HPCC applications, and the task of managing the flow of such large amounts of data in a fully digital computer network;

-- the planning, implementation and operation of HPCC networks will be complex and extremely expensive;

-- the pricing of HPCC to cover private and public costs and the costs of future developments presents major difficulties;

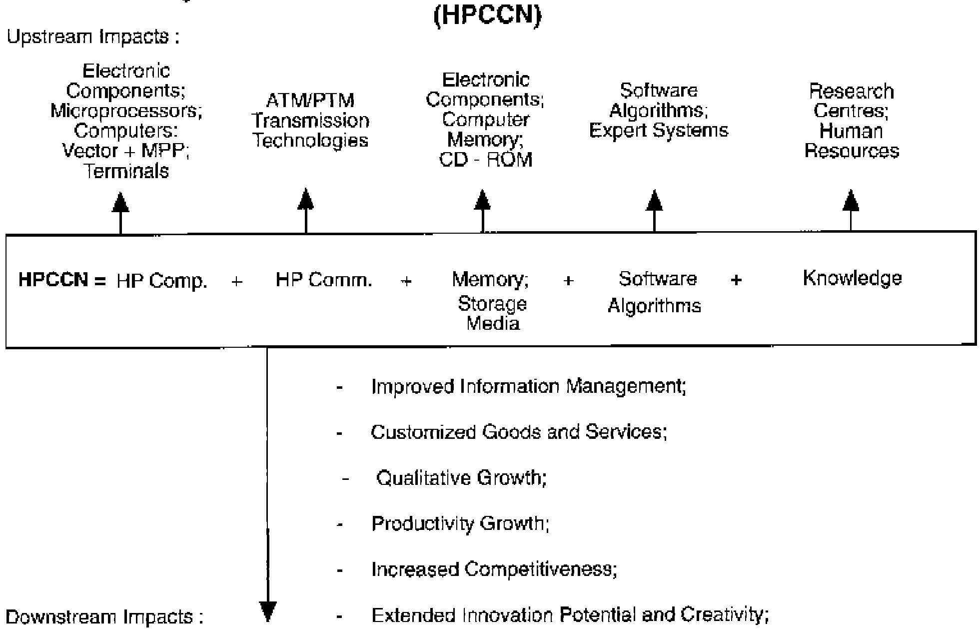
-- identifying perspective users and their requirements is fraught with uncertainty; and

-- using information as a new resource requires major organisational adjustments.

Site visits in Europe, Japan and the USA were aimed at obtaining some insight and conceptual information about currently available experiences in these fields and at learning about HPCC policy initiatives in these Member countries.

Figure 2

High Performance Computer-Communications Networks (HPCCN)



Chapter 3: Findings and Conclusions

3.1 Emerging information infrastructures

Recent breakthroughs in information technology (IT), primarily computers, fibre optics and satellites, digital switching and transmission, and in the ways these systems are being used, mean that advanced OECD economies are now at a cross roads in restructuring their information infrastructure. The issues at stake are complex and the technology is changing rapidly. National policy makers and industry therefore need objective information and analysis of international trends on emerging IT applications and resulting IT processing, storage and transmission requirements for their own planning and to facilitate the development of national and global networks.

This project is a preliminary attempt to gain insight into the process of developing advanced computer-communication network infrastructures and the basic technology/industry relationships. It has three primary objectives:

-- to collect basic information on a selected group of national experiments and national R&D programmes to support the development and implementation of HPCC networks;

-- to determine the degree to which usable and comparable data, studies, and analyses might be available; and

-- to tighten and refine a broad, preliminary list of research questions for a more continuous monitoring of developments in HPCC and its driving forces.

3.2 From supercomputers towards HPCC networks[8]

The visits confirmed the shift from mainframe-based, centralised structures toward a more distributed computer environment. The new concept comprises a spectrum of various types of computers such as:

-- workstations;
-- high performance workstations;
-- file servers;
-- mini-supercomputers;
-- supercomputers with multiple vector processing units;
-- massively parallel computers.

These are interconnected by high performance communications networks distinct from the current telephone network to build Local Area Networks (LANs), Metropolitan Area Networks (MANs) and Wide Area Networks (WANs) extending the reach and distribution of HPCC throughout the economy. In addition to these hardware components, HPCC includes the development of advanced software and algorithms, and investment in human resources to enhance and deploy the new information processing power.

The applications of traditional supercomputers have changed accordingly: standard batch and interactive applications on mainframes are increasingly being replaced by client-server type applications, such as fast file transfer, computer-aided design, on-line visualisation of simulations, highly parallel numerical algorithms and multimedia applications executed on a distributed computing architecture.

These developments are no longer technology-driven, but rather reflect the ever growing demand of the science and industrial research community for computation power, data bases and related information resources. Extremely large amounts of computing power are increasingly fundamental in these areas and, indeed, vector supercomputers have revolutionised how basic and applied R&D are now performed. When it became clear in the late 1980s that the speeds required could no longer be sustained as the technology was starting to approach physical limits (e.g. limits of CPU size, communications and heat dissipation), new solutions were sought to meet the new demands. Consequently, serious attention began to be focused on parallel computing architectures as a way of continuing to deliver the performance increases that science was demanding. Parallel computers have hundreds or thousands of interconnected processors that work simultaneously on a problem.

One of the most significant developments in High Performance Computing (HPC) is that nearly all architectures -- vector and parallel -- have begun to converge into hybrid vector/multiple instruction multiple data (MIMD) machines. These are machines that typically have between 100 and 1 000 autonomous processors, each with its own memory and each incorporating a vector processor. Within this basic configuration, it is expected that the growing computing and processing requirements (in terms of capacity and speeds) of the emerging grand challenges can be provided. In summary, the characteristics of grand challenge problems are that their solution requires on the hardware side:

-- computers capable of speeds of at least one teraflop; [9]
-- main memory in excess of one terabyte;[10]
-- an extensive high speed (gigabit range) communications infrastructure.

As the solution to grand challenge and related problems is claimed to lead to a major increase in scientific or industrial performance (and subsequently enhanced competitiveness), most of the HPCC initiatives examined aim at developing these enabling tools with capacities ranging from a few tens of megaflops to gigaflops and even teraflops.

3.3 High performance communications

Bringing these high performance computer capabilities to the users is at this stage limited by the prices charged and the technical (switching and bandwidth) capabilities of existing networks. From the site visits, it became clear that research and experiments are tackling these bottlenecks along basically two directions: *first*, through upgrading the performance of the ordinary analog telephone circuits through digitalisation (ISDN strategy); *second*, by establishing a digital switched high-speed network with flexible data transmission speeds (bandwidth à la carte -- broadband-ISDN or B-ISDN strategy).

The second strategy is the really innovative approach and an international race has started to establish an industrial research and production base in this field. The key to providing the functions required in the high speed network approach is, on the technical side, ATM (asynchronous transfer mode) and fibre optic networks; on the economic side, it is competition, to make sure that the new systems are deployed in markets at affordable prices.

ATM results from a number of technological achievements including optical fibre cables and progress in VLSI technology. With the introduction of optical fibre into communications networks, transmission errors diminish. This enables the transport network to dedicate itself entirely to information transfer by delegating most flow and error control to the terminal or a computer. Advances in LSI technology enable systems to process protocols and perform switching economically and automatically without software control. In ATM networks, digitised voice, data, and video signals are divided into pre-defined 53-byte blocks (cells). The system gives each cell a header with a destination. While the cells resemble conventional packets, the fixed length simplifies the protocol so transmission can take place on a hardware, rather than a software, basis.[11] Hence computer communication convergence is finally accomplished with storage, processing, switching and transmission as integrated functions in a fully digital environment. This contrasts with the current solution, where the weakness of communications limits the capacity usage of the computer segment.

High performance computer communications designed around ATM and optical fibre networks, however, seems to permit *more than merely providing new computer-supported applications and services. It also promises to revolutionise traditional voice, data and video communications and their integration, opening new venues for the development of entirely new information infrastructures.*

The site visits focused mainly on advanced communications systems, and applications designed around the use of advanced computer systems. The following section considers some of the different approaches currently being pursued in the countries visited.

3.4 An international comparison of emerging trends

One clear lesson from this study is that, in each of the regions, markedly different approaches to enhancing advanced computer communications infrastructure are pursued.

3.4.1 Japan

In Japan, technical improvement in the national communications network has to date focused on the accelerated introduction of narrowband ISDN (integrated services digital network) services. First introduced in 1988, ISDN services in Japan have been promoted with aggressive investments by NTT (Nippon Telegraph and Telephone Corporation). By the time of the site visit in July 1992, over 100 000 basic rate access lines had been installed. Particularly notable was the installation of over 2 800 ISDN-capable public telephones over this period.

On the computer-communication network-side, a research network was established in 1987 and Internet Protocol (IP)-based services started in April 1992 by the National Center for Science Information Systems (NACSIS). A nation-wide network is planned jointly by the Science Technology Agency (STA), Ministry for International Trade and Industry (MITI), Ministry of Posts and Telecommunications (MPT), and the Ministry of Education. For the business community, AT&T and JENS (Japanese Electronic

Network Services, a special Type II carrier for domestic and international value added services) have started to offer IP services on a commercial basis.

The big player, however, is NTT, now a private corporation. The Study and Research Group on B-ISDN of the MPT presented an estimation of investment in broadband ISDN to provide services to all business and virtually all homes by the year 2015. Paying for the massive investments required, however, seems to be the subject of considerable discussion. An increasingly competitive environment in domestic long distance traffic, where NTT no longer has a protected monopoly, will also be an important factor forcing NTT to focus on economic returns.[12]

Co-ordination among government institutions seems to be playing an increasingly important role in the modernisation of the communications network infrastructure in Japan. The Ministry of International Trade and Industry (MITI) is funding some network-related investments as part of its Real World Computing (RWC) programme. This includes establishing an international network for promoting co-operative work among researchers all over the world. The Ministry of Education does have ambitious plans to connect educational institutions with an IP network. The Ministry of Posts and Telecommunications does sponsor research at both its own Communications Research Laboratory and outside involving some 2 billion yen (approximately US $ 17 million in fiscal 1993). This programme involves research on technological and organisational problems, to ensure interconnectability, crucial for an inter-carrier network.

The government's recently announced US $ 117 billion economic recovery plan to stimulate the flagging Japanese economy has set aside additional funding for building an intelligent computer communications infrastructure for the 21st century.[13] Focusing on computer-communications technology, will help rapidly to extend Japan's research and industrial production capabilities in this area.

With a view to further enhancing the research base in this area, the Japanese Government plans to establish an inter-agency network.

3.4.2 The United States

The evolution of high performance networking in the United States has been intimately linked to the creation of the Internet, a TCP/IP-based computer communications network that began as a research project -- the ARPAnet -- funded by the Department of Defence. In recent years, the standards and protocols developed for that initial experiment have been further augmented and deployed as the core of a large scale network linking U.S. academic institutions, partly financed by the National Science Foundation. Today, the Internet is a loose collection of interconnected IP networks involving over 1 000 000 computers, linked by a core backbone that continues to receive significant support from NSF. The Internet today connects some 3 million government and academic computer users, along with an increasing number of commercial enterprises and foreign users (growing at 12 per cent per month).

One unique feature of the U.S. Internet is the manner in which it was constructed. This packet-switched communications network was created as an entity that was functionally independent of the public switched telephone network, though public communications carriers do provide private data transport services on different links within this collection of networks. Because it was conceived as effectively separate from the public switched telephone network, and primarily designed to serve a government, non-profit, and educational community, it evolved free of the regulatory and other constraints faced by the public telephone network. As a testbed for developing new communications network and application technology, it also permitted a degree of experimentation that would probably not have been available to developers working on the commercial, public switched network.

Many services first developed for experimental use on the Internet are now in increasingly wide commercial use. It is probably fair to say that the current widespread use in the United States of electronic mail, file transfers among widely distributed computers, and remote log-ins to physically distant computers, owes much to the accelerated development of the Internet. New services and applications, such as video, fast, remote retrieval of high quality text and image data (digital libraries), and distributed information servers (like the Gopher[14] and WAIS applications) are only the most visible edge of a whole new generation of applications that will consume the increasing amounts of bandwidth available on the Internet as it is modernised and upgraded.

Current national efforts to upgrade communications infrastructure in the United States take two distinct paths. The High Performance Computing and Communications Initiative (HPCCI), in addition to funding R&D on new computer architectures and software algorithms, puts significant resources into a National Research and Education Network, the NREN. Other resources are being invested in a number of testbed projects created to experiment with the technologies used in very high speed (gigabit) networks. These government supported efforts focus on investment in understanding the problems and creating the basic technology required to deal with gigabit data rates, and supporting major growth in the networks linking educational and research computer users.

The second major set of initiatives involves the upgrading of the public switched telephone network. One major side effect of the deregulation of the long distance telephone market in the United States has been the entry of a significant number of new companies into this business, and the creation of a highly competitive business environment. Not only conventional long distance voice telephony, but also digital leased lines have plunged in price. A substantial cheapening of digital data bandwidth has clearly been one of the factors driving the extraordinary growth in wide area networking in the United States. At the end of 1991, for example, U.S. local exchange carriers had installed about 11 000 miles of optical fibres carrying data at DS-3 rates (45 megabits per second or greater), which terminated on customer premises. Generally, circuits delivering these data rates are unavailable commercially in Japan or Europe.

Currently, the major public communications carriers are offering a variety of new digital data transport services, including so-called fractional T-1, frame relay packet-switched services and switched multimegabit data services (SMDS). Many carriers have also now announced the introduction of services based on asynchronous transfer mode (ATM) into their networks. ATM technology allows both voice and other data to be prioritised and transmitted over a single communications system at rates up to or eventually exceeding a gigabit per second, and promises to be the uniting technology which brings together the now separate world of Internet-style packet-switched networks with the public switched telephone network, in a single seamless, ubiquitous network.

In 1991, the government launched the NREN programme. The programme has the aim of reintegrating research and development in enhanced high performance computing (Teraflop and beyond) and communication networks (gigabit range) to provide the tools for the "Grand Challenges". Ultimately, this programme will lead to the establishment of a National Research and Communications Network to interconnect some 250 universities and major national and private research laboratories in the USA. Currently a number of testbed experiments are under way to determine the future requirements of these institutions and hence to assist in the capacity planning and development of such gigabit networks and their components. **Figure 3** identifies these testbeds and shows their geographic deployment in the United States.

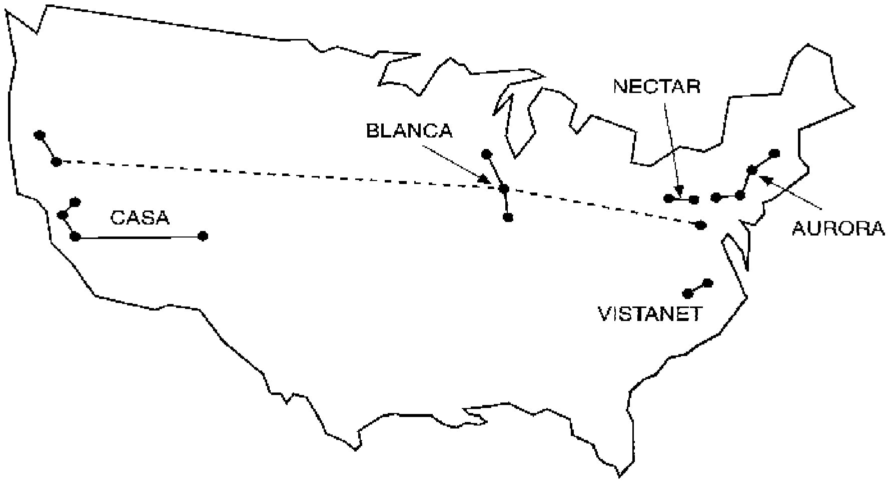
3.4.3 Europe

In general, the members of the OECD research team were impressed with the strong research base and impressive laboratory and demonstration projects observed in Germany. The experimental applications viewed reflected a high level of quality and innovation.

However, German and CERN network users in Switzerland complained about the high cost and the limited availability of high performance digital data transport facilities on the public network in Europe. Basic leased data circuits, generally supplied by Public Telecommunication Operators (PTOs) holding a monopoly position, are commonly up to five times the price of equivalent services in the USA.[15] Unlike the case in the United States, a packet-switched IP network infrastructure independent of the PTOs was not

Figure 3

GIGABIT TESTBEDS IN THE UNITED STATES



Source : Status Report on the European Gigabit Initiative, R. Popescu-Zeletin, DETEBERKOM / GMD, Berlin 1993, p.1.

allowed to develop. As a consequence, though the Internet has grown rapidly in Europe in terms of nodes and connectivity, the bandwidth connecting these nodes has grown only pitifully, and high performance computer users are quick to complain about the low effective communication rates with other sites in Europe.

In February 1993, a plan for a pan-European backbone for TCP/IP and X.25 packet-switched traffic, offering speeds up to 2 megabits per second, was announced by the European Community. Though a much-needed upgrade to Europe's network infrastructure, this falls far short of the 45 megabit per second links already used on the backbone of the U.S. NREN system.

The fundamental obstacle to rapid improvement in performance of the network infrastructure in European countries would appear to be the attitudes of European PTTs, who see no significant commercial market for data transport services at very high bit rates. Coupled with the resistance of supercomputer centres and other high performance computer users to paying very high tariffs for relatively limited bandwidth, this creates a chicken-and-egg problem of sorts.

One promising route for breaking this impasse appears to be visible in the United Kingdom. There, SuperJANET (the British research equivalent of Internet) has rapidly upgraded the cross-section of its communication links at relatively low cost, as some degree of competition now exists. This drives home a key point: in Europe, rapid progress in high performance networks seems intimately related to the future market structure of the data communications industry, which for the most part remains firmly in the hold of monopolies.

In some European countries, a number of application-based pilot projects are underway exploring the transmission and switching requirements of advanced computer-communication applications. The sites visited include:

-- BERKOM, Berlin (multimedia electronic publishing, CIM, City planning);
-- TUBKOM, Berlin (medicine, education, network management);
-- RUS, Stuttgart (simulation, CIM, CAD, Collaborative Research);
-- ICA, Stuttgart (CIM, Visualisation, Fluid Dynamics);

-- CERN, Geneva (Distributed Computing, Information Resources).

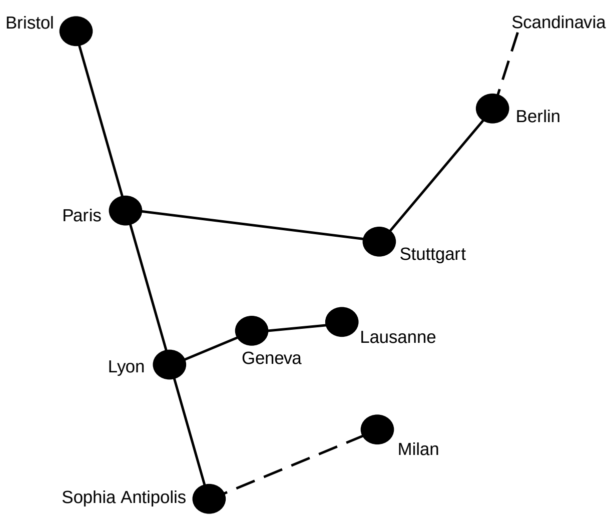
As infrastructure services still fall under national responsibility, the situation with cross-boarder networks, such as HEP (High Energy Physics) and EARN (European Academic Research Network), is particularly difficult. In the context of EUREKA, COSINE (Co-operation of Open Systems Interconnection Networks in Europe) has been mandated to improve this situation. Similarly, for higher speed networks to meet the future requirements of the European scientific community, RARE (Réseaux Associés pour la Recherche Européenne) is developing new concepts. RARE's efforts to promote and participate in the creation of a high-quality European computer communications infrastructure led in July 1993 to the creation of DANTE (Delivery of Advanced Network Technology to Europe Limited). This company was established by the national members of RARE, the European Association of Research Networks. DANTE's main service is EuropaNET, a combination of pan-European backbone services, gateways to other networks and intercontinental connectivity to the United States. To meet the growing demand for higher speed networking, DANTE is preparing a next generation backbone (34 Mbps and 155 Mbps) at a later stage.

The main policy initiative on a Europe-wide scale is the RACE Programme (Research and Development in Advanced Communications Technologies in Europe) of the CEC. RACE aims to develop and operate high performance networks by 1995. At this stage, discussions with the different European Telecommunication Organisations (TOs) foresee three networks:

-- EBIT (European Broadband Interconnection Trial);
-- METRAN (Managed European Transmission Network);
-- GEN (Global European Network).

The tentative network layout of the last (though the list of the members of the R&D and user community is not finalised) is presented below (**Figure 4**).[16]

Figure 4. **Planned European HPC-Network**



Source: Status Report on the "European Gigabit Initiative", *op. cit.*, p. 47.

The implementation of a full-fledged computer-communication infrastructure across the European Communities would require massive and sustained joint efforts on the part of the European authorities. The new CEC White Paper on growth, competitiveness and employment (December 1993) infrastructure (rail, road, maritime, information) foresees CEC spending of around ECU 120 billion over the next 6 years; public and private investment could mobilise over ECU 400 billion for all infrastructures taken together.[17]

3.5 Economic and technological stakes

In the preceding chapter, it has been argued that new industrial needs and emerging applications are fostering the development of new computing capabilities and computer configurations. Visualisation, simulation and optimisation requirements of advanced users, simultaneous collaborative research and development, and the need to draw on huge data bases and related information resources are leading to high performance configurations operating in a local or wide area environment. These developments are not merely technical matters; they have major economic and technological policy dimensions.

3.5.1 Economic stakes

Even in its yet embryonic forms, HPCC -- mostly in a LAN configuration -- has already proven its economic and strategic importance in numerous scientific and industrial applications in all countries visited.

At the firm level, the group has discussed documented examples that HPCC is cutting R&D costs and time to market products and services. It permits rapid experimenting with more design and performance options in the development of goods and services. Examples reach from household appliances (safer and less electricity consuming stoves) to automobiles (investigating properties of new car designs, improved aerodynamics to reduce petrol consumption, and analysing crash behaviour), to the design of less noisy and less energy consuming aeroplanes. HPCC is also used as a tool in the design and testing of hip and teeth implants, and for intricate surgery in human medicine. Other major uses are weather forecasting and advising policy makers with econometric modelling.

So far these benefits have been exploited by a few large firms. Extending the potential and reach of these systems through improved switching and transmission technology could well permit huge economies of scale and scope and hence lead to improved cost/performance ratios. These are characteristic of electronics and IT in general, and have been essential for its diffusion. HPCC thus may become more affordable to the medium- and small-sized firm.

Experts therefore predict that in industrial sectors, annual gains in productivity from 1-6 percentage points until the year 2 000 will result from HPCC.[18]

The importance of HPCC networks as an information infrastructure may be even more far-reaching at the macro-economic level. As most of the scientific and industrial research of an economy may function through, or be based on, HPCC, it may alter significantly the innovation capabilities and the "innovation system" of an economy.

The innovation process likely to be triggered seems to follow the dynamics described below:

1) There is a close relationship and mutual interdependence between scientific and industrial research and HPCC. The "real time" information processing, storage and exchange requirements of these users significantly spur new IT and related developments; and

2) These IT advances in turn enable further progress in most science and engineering areas. Advanced computing systems permit the simulation of complex research questions and are instrumental for the determination of optimal solutions. In fact "Computational Science" in terms of a new science field is developing at cross-roads of the classical disciplines (mathematics, physics, chemistry, computer science, etc.). Hence the computer becomes not only the product of the most advanced technology but also a necessary tool to advance basic science and technology. This mutual relationship between IT and technological innovation in general, is gaining a central position in the innovation process of industrialised societies. This interaction of HPCCN with basic and applied research may increasingly define the innovation

> potential of an economy and is therefore seen as critical for further economic and social development of advanced nations.[19]

HPCC -- in the form of an enhanced information infrastructure -- through investment in research, machinery, related equipment and high value services (software) not only promises high social returns, but may also attract substantial private investment because of the prospect of increased private returns through its use downstream in the economy.

3.5.2 Technological stakes

Focusing on leading edge applications will also send early signals to the IT manufacturing and related industries upstream for the development of new technology and systems, including microprocessors, computers, workstations, telecommunications, software, etc. Experimenting with emerging applications with the IT manufacturing industry improves information flows and permits real time feedback loops between users and manufacturers. This leads to a wider creation of knowledge and know-how and permits consideration of the particular economic and technological requirements of each application or user industry. This application-rooted innovation process in HPCC networking facilitates the enhanced, systematic exploration of improvements in all the segments constituting the network. In addition, the various steps in the development and design phase of new IT equipment and operating software run in parallel (simultaneous engineering). Finally, in the implementation and usage phase of HPCC systems, the demand for the different equipment and services constituting HPCC [i.e., computers, transmission and switching facilities, software, Artificial Intelligences (AI), expert systems and related goods and services] will spur verticalisation in the major HPCC segments through forward and backward integration. This process is also depicted in a stylised way in **Figure 2**.

Ultimately, the implementation and usage of HPCC supported information infrastructures may trigger what Kenichi Imai (1983) has termed "forward breeding mechanisms" prompting horizontal/vertical multiplication in the division of labour as new HPCC products and technologies seek use and applications. These horizontal/vertical chain reactions driven by a mix of entrepreneurship and new technological opportunities to process information and create new insight may occur both on the HPCC supply and down stream in the HPCC user industries. On the supply side these forces reflect the demand for the different equipment and services constituting HPCC systems (electronic components, computers, transmission and switching facilities, software, AI, expert systems and services) and nourish the development of firm clusters in the major HPVCC segments (see upstream impacts in **Figure 2**); similar processes occur in the HPCC user industries as closer feedback loops between producers and users facilitate product and service diversification and the development of new product lines which is the humus for the creation of new firms and new employment opportunities. Accordingly, verticalisation, e.g. the establishment of supporting and/or competitive manufacturing firms and users in each of the different HPCC segments listed in **Figure 2** (see upstream impacts), has been recognised as important for the innovative process and sustained development in developed economies.[20]

However, this interdependence between the development/production and use of systems may increase the risk of locking in users and suppliers to each other, ultimately stultifying innovations. Attention should, therefore, be paid to the design and functioning of different types of networks structures so as to identify the most opportune arrangements for useful information flows.

Exchanging information on this user/manufacturer interaction in the design and experimental phase of HPCCN is also crucial for countries which do not have major computer research and production capabilities. Advanced information on the evolution of high speed computer communication networks and applications will help these countries to anticipate and plan for their own future role. In addition, this insight helps to determine to what extent existing comparative advantages in different industrial activities might be affected, and where new opportunities are arising. Early familiarity with HPCC then allows users to develop appropriate niche and other strategies.[21]

3.6 Public Policy and Programmes for HPCCN

Introduction

Most OECD countries rely mainly on market mechanisms for the development, production, and diffusion of new technology based products and systems. However, in the case of computer networks and information infrastructure, there are a number of market barriers and deficiencies. These include the presence of important economies of scale and scope, huge learning by doing costs, the extraordinary nature and degree of uncertainty involved in the networking process, the need for large-scale experimentation with alternative approaches, and the co-ordination of a wide range of players involved both on the supply side and on the usage side of such networks. As a consequence, the HPCC site visits found much public policy in all facets of HPCC, ranging from defensive measures (with focus on consensus finding in the mapping of the direction of research programmes or the opening of niches for HPPC) to rather aggressive approaches with direct public funding for HPCC technology, application support and the provision of low cost capital for longer term projects.

3.6.1 The United States

The US$ 3 billion HPCC initiative involves a long-term and detailed programme for HPCC. It pursues clear objectives and strategies, including real world competitive experiments and the establishment of pre-competitive testbeds. Major goals and strategic priorities are to:

- extend U.S. technological leadership in high performance computing and computer communications;
- provide wide dissemination and application of the technologies both to speed the pace of innovation and to serve the national economy, national security, education, and the global environment;
- spur gains in U.S. productivity and industrial competitiveness by making high performance computing and networking technologies an integral part of the design and production process;
- support solutions to important scientific and technical challenges through a vigorous R&D effort;
- reduce the uncertainties to industry for R&D and use of this technology through increased co-operation among government, industry, and universities, and by the continued use of government and government-funded facilities as prototype users for early commercial HPCC products;
- support the underlying research, network, and computational infrastructures on which U.S. high performance computing technology is based; and
- support the U.S. human resource base to meet the needs of industry, universities, and government.

In addition, the HPCC initiative, extended by the US Bill on National Information Infrastructure (NII) and other matters,[22] is application driven and supported by all the major players involved in the supply and usage of HPCC and related functions.[23] The President of the United States and the US Government have given a high level of support to this initiative.

3.6.2 Japan

Japan, like the United States, has a well-established manufacturing base in supercomputers (Hitachi, Fujitsu, NEC and alt). There is also extensive government involvement in HPCC including: MITI’s new 10 year Real World Computer (RWC) programme (some US$ 600 million), aiming at developing flexible information processing technology similar in function to the characteristics of the human brain. The Study and Research Group on B-ISDN of MPT estimated the amount of investments to establish a broadband ISDN network by the year 2015. NTT will use fibre optic cable to service homes and businesses, enabling transmission of digitised voice, data and video traffic at high speed. Though there was no detailed information on the application to be serviced on this high speed network, investments of such an order will definitely strengthen the research and industrial base of Japan to supply HPCC-ATM related equipment and systems.

These programmes include some seemingly broad policy objectives for preparing Japan for the 21st century:

- -- informatisation of the economy;
- -- decentralisation of industrial activities;
- -- regional development.

These topics have been discussed in many industrial and economic circles with the broad participation of the media. Consequently, there is widespread awareness of the economic and social significance of HPCC, and IT in general. To give just one example: the notion of informatisation incorporates clear economic and social objectives, such as more intelligent products and services, reduced pollution, enhancement of innovations, greater competitiveness, and larger markets.

Policy measures to support the implementation of advanced digital networks and to prepare for the expected fundamental changes in the Japanese economy also include special depreciation schemes for older technology-based systems and related sunk capital, low interest governmental loans, and governmental guarantees for debts.

Though these broad measures may enhance significantly Japan’s industrial base in HPCC, the current lack of targeted applications may incur penalties. MPT is therefore supporting a pilot project on B-ISDN application in the Kansai region as of 1994. It is expected to promote the development of appropriate software and mathematical algorithms to tackle grand challenge applications.

3.6.3 Europe

Site visits in Europe were restricted to Germany and Switzerland. Europe, at this stage, has no comprehensive programme for HPCC developments in the gigabit/teraflop range. Through the different generations of ESPRIT and RACE programmes, the Commission supports the development of advanced computers and communications networks respectively. Some countries [for example, Germany (DFN), Finland (FUNET), France (Renater) and the United Kingdom (SuperJanet)] have started, or are considering, national programmes in this area. These projects aim at testing ATM-based wide area network architectures operating typically at 34 Mbps speeds with the potential to be up-graded to 155 Mbps. In addition, there are a number of centres of excellence experimenting with high performance computing and high performance communication networks as separate entities, each supported by public funding by the respective national governments and/or benefiting from R&D support through the IT Programmes (ESPRIT, RACE and Telematics) of the CEC. Research network connections across national boundaries within Europe are co-ordinated by RARE (Réseaux Associés pour la Recherche Européenne). In particular, RARE’s Dante Unit (Delivery of Advanced Network Technology for Europe) plans to provide 8 Mbps services in the near future.

With emphasis on advanced communication technologies, the CEC is encouraging the development of broadband network concepts (e.g., Integrated Broadband Communications -- IBC) and there are a number of co-operative broadband (B-ISDN) trials planned by the European telecommunication carriers:

-- European Broadband Interconnection Trial (EBIT);
-- Managed European Transmission Network (METRAN); and
-- Global European Network (GEN).

The main difficulties in Europe seem to result from organisational/institutional, technical and regulatory constraints associated with developing services across national borders. In the absence of a competitive endogenous computer industry, and exposed to increasing competitive pressure in the communications sector, telecom operators (TOs) seem to have a rather defensive attitude towards HPCC. As a consequence, HPCC is rather narrowly defined; broadband seems to start as low as 34 Mbits/s compared with 600 Mbits/s transmission speeds in the United States. The focus of TOs is mainly on delivering services based on clear commercial criteria. They do not see a real demand from the customers for higher speeds in the near future.[24]

Where HPCC applications use telecommunication services in Europe, the costs can be prohibitive. Telecommunications tariffs for computer networking can be as much as 5 times higher than those in the USA. An exception to this situation is SuperJANET in the United Kingdom, which enjoys support from DTI and benefits from a competitive telecommunications environment.

The most prominent effort towards a comprehensive European programme for HPCC is the Rubbia Report commissioned by the CEC. This report suggests developing HPCC in the emerging socio-economic and industrial context and proposes an investment programme of ECU 5 billion over a period of ten years.[25]

3.6.4 Concluding comparative observations

The site visits clearly confirmed the economic and technological importance of HPCC system both downstream as they are used throughout the economy, and upstream through the development of a wide range of IT research and production capabilities, including microprocessors, computers, workstations, network architectures, transmission and switching technology, software, algorithms, AI and human resources and skills.

To exploit this potential to the fullest extent, HPCC cannot be reduced to computing or communications. In particular through ATM technology, optic fibre cables, and progress in Very Large Scale Integration (VLSI) technology, HPCC has become *a single entity*. It is no longer possible to distinguish where computing, switching and transmission start or end. Each function determines the performance of the other. In addition, HPCCN not only permits new services involving the processing of huge amounts of information, it also has the potential to improve traditional telecommunications services at lower cost.[26] In this sense HPCC is more than merely the sum of the different IT parts.

For the design and development of the entity HPCC around emerging and future applications and usage patterns, close co-operation among advanced information resources (data bases, libraries), user communities and the IT manufacturing and related industries and policy makers is essential. Ideally, this mutual interdependence between applications and HPCC systems to meet the needs of advanced users may trigger a continuous stream of innovations simultaneously in both sectors, and maximise the chances of reducing the number of acceptable network alternatives, vital for economies of scale and scope.

At this stage, however, there are significant differences in approaches towards HPCC. This largely reflects the current distribution of research and production capabilities for the different HPCC segments, the industry structure and the policy objectives pursued when preparing the industrial future in the countries concerned.

In the three OECD regions reviewed, the *United States* holds a lead position in research and production of supercomputing equipment, including vector and massive parallel systems, software, advanced ATM and transmission technology.

Japan, similarly, has a strong research and industrial base in supercomputers. Both vector and high end-parallel processing machines and their usage are widespread. Her position is said to be weaker in parallel machines involving numerous low-cost high speed microprocessors as alternatives to high cost large general purpose systems. These low cost parallel systems, which are reported to benefit from a venture capital environment, seem less developed in Japan. However, Japanese firms, such as Fujitsu, Mitsubishi and Matsushita have developed several commercial parallel machines and are enhancing their effort for developing a new parallel processing system.

Europe has no endogenous supercomputer base; prototype parallel high performance systems (for example, the Transputer TP 9000 developed by Parsytech in Germany and Archipel in France), designed around sophisticated software and algorithms exist, and commercialisation is expected to start in the mid-1990s. The European industry seems to be on equal footing with the USA and Japan in advanced communications and ATM technology, and there is a rich body of experience in HPCC applications and supporting systems.

All three, then, have acquired comparative advantages in HPCC research, and co-operation would be beneficial to each. Co-operation will also be necessary for other strategic and economic objectives, requiring broader availability of HPCC. This will determine the infrastructure economies to be yielded and the future size of the industrial base in these strategic areas. In particular, agreements are required to provide critical mass and economies of scale to bring costs and prices down in a competitive environment.

From the discussions at the sites, it became evident that there is more than one solution to the planning of HPCC performance levels and that there are numerous HPCC network concepts and competing alternative network configurations to distribute enabling HPCC capabilities.

The preliminary examination of some selected HPCC experiments and national HPCC policies suggests that a great deal of useful information is available, both hard data and more subjective, qualitative information. This information could undoubtedly be of use to policy makers as they make critical decisions on national infrastructure issues over the next few years.

In the first place, investment decisions on the infrastructure will need to be based on some conceptual models of cost/benefits, technological trends, and potential user demand. These models will necessarily be speculative and hypothetical, as is nearly always the case with infrastructure decisions. Because infrastructure investments are very long-term, they must account as best they can for technological change, for innovation in new services and applications, and for changing usage patterns among individuals and organisations.

At this stage, some nations are ahead of others in deploying certain advanced technologies, or are deploying them in unusual and interesting ways. Their experiences can provide some practical checks on policy assumptions in other countries.

For instance, a debate is now taking place in many countries on whether to focus on deploying a very high speed, advanced technology network, probably based in large part on optical fibre, or to encourage an intermediate infrastructure based on ISDN. Some countries already have experience with ISDN, which provides enhanced insight into its costs, utility and emerging usage pattern. In the same way, to give another example, examining the French experience with Minitel could give insight into the use, utility, and technological demands of new home information services.

Beyond simply providing some better information on which to base decisions, study of existing experience in computer networking in OECD Member countries will also prepare policy makers for the international aspects of infrastructure building. There is already an international network of carriers and services from which much can be learnt. Firms, governments, not to mention other organisations and individuals citizens, have come to depend on seamless interconnections and information flows free of unnecessary barriers.

National choices on technology, pricing, and interconnection standards at all levels, as well as information policies, will naturally differ, especially to the extent that they reflect different national needs, social values, and visions of the future. None the less, they also need to be synchronised so that the sum total of these national decisions results in co-ordinated global networks. Once again, careful study of national programmes can help provide useful insights into emerging trends.

Figure 5 illustrates the foci of current HPCC developments in each of the three regions of OECD. They should not be taken to show that one region is necessarily more advanced than another, simply that they are developing differently and have different strengths. The diversity of these developments strongly suggests the need for co-ordination if a range of experience is to become a strength rather than a weakness.

3.7 Conclusions and implications for further HPCC actions

It would be extremely useful to interlink some of the testbeds in the United States, Europe and Japan.[27] This might shed light on likely usage patterns and their technical requirements, and indicate what HPCC configurations are most appropriate and what international usage can be anticipated.

3.7.1 New interlinked testbeds for HPCC

It would also be appropriate to select more challenging applications for experimentation: candidate examples include research, development and industrial/engineering applications. In addition, commercial and administrative areas should be targeted: numerous public service applications such as education, libraries, public health and transportation and delivery of social services are critical application areas for HPCC research and experimentation. Applications of this type would go far beyond present data transmission capabilities and would require an extensive HPCC infrastructure.

It might be appropriate to set up in each Member country a tentative international community project, developing and providing new services over advanced networks. Such an effort would help identify evident legal, technical, and social issues; provide a place for industry to test and develop future products and ideas; and, more importantly, provide practical examples of the potential advantages and disadvantages of HPCC systems.

Figure 5

HPCC Policy Focus and Public Funding

HPCC Components / Countries/ Regions	HPCC Applic-ations	HP Comp.	HP Comm.	Main-Memory, External Storage	Software	Industrial Investment Plans (billions of US$)	Research + HPCC - Centers of Excellence	Public Funding (billion of US-$)
USA	X	X	X	X	X	450[1] (1993-2015)	X	3 billion (1991-1995)
Japan		X	X			250[2] (1992-2015)		0,6 (1992-2002) RWC
Europa	X		X		X	160[3] (1994-1999)	X	Rubbia Report : 3,5 billion ECU

1. An " Infostructure" For All Americans: Creating Growth in the 21st Century, April 1993, Ameritech, Bell Atlantic, Bell South, NYNEX, Pacific Telesis, Southwestern Bell, US West, page 3.
2. Estmates of the Study and Research Group on B-ISDN of the Ministry of Posts and Telecommunications, Tokyo, July 1992
3. CEC White Book (Delors Plan II) : Growth, Competitiveness, and Employment, Bruxelles, 10 Dec. 1993.

Each of the countries visited have such experiments in early stages of planning and experimentation. At this moment, for example, Japan is preparing a 10 billion yen project to test the next generation of optical fibre network in the Kansai Science Park City (near Kyoto).[28] Similar testbeds are carried out or might be installed in other OECD regions.

Governments can provide leadership. Public bodies could help by creating high-performance networks amongst centres of excellence in *public* research and development. Commercial research and development centres could join these networks on their own expense. This strategy would cost a relatively small sum compared to the large investment necessary for a whole new broadband infrastructure. This approach could be an essential starting point to building a comprehensive infrastructure. Accordingly, with a view to stimulate the formation of information super highways, the USA has chosen to provide seed money for applications that demonstrate the use of HPCC.

Government influence in reducing existing barriers and constraints, and creating competitive market environments, is uncontested. This is a reminder that there is nothing automatic about the introduction of new technological opportunities: rather prices and new market opportunities determine the broad diffusion of high technology-based systems. In the case of infrastructure, government leadership has indeed always been decisive in reducing private costs and stimulating private sector R&D and investment.

Europe might gain particular advantages from greater awareness of, and co-ordination with, HPCC applications elsewhere. Within Europe, advantages can be realised by linking existing (or planned) islands of HPCC as a prelude to their integration with HPCC activities and applications in the rest of the world. This is, however, unlikely to happen if European policy for HPCC is not co-ordinated.

The development of HPCC cannot be left to disparate groups of scientists and researchers, a few progressive firms, and the occasional attention of some government departments. OECD is particularly well positioned to provide an international forum in which those in the worlds of research, industry and government may meet to discuss common interests in HPCC and to formulate common plans for its future development. At the moment, senior management on both industry and government lack the expertise HPCC researchers might provide.

Interconnectivity and complementarity of HPCC technology and systems with conventional telecommunications is yet to be determined, as is its impact on the pricing and provision of traditional telecom services. Up to now, HPCC has commonly been considered as an additional new service. Its capacity to alter existing services and eventually integrate the new with the old in the advent of digital telephony and mobile communications has not yet been fully appreciated.[29]

3.7.2 Development of need of HPCC data and knowledge bases

Future high performance computer communications based architectures will need to be highly flexible and adaptable. This, of course, makes managing technological systems developments more difficult and challenging. To facilitate this process and permit an integrated and timely co-ordinated development path in and between Member countries, the systematic collection of information on current and planned HPCC experiments together with the regular evaluation of their policy implications would be valuable.

Future studies of HPCC therefore could explore some of the following themes:

i) national efforts to deploy advanced digital communications technologies and the structure of costs associated with different technological choices;

ii) the pricing of, and utilisation of, various digital communications services across countries;

iii) leading edge applications and what is known about their usage patterns;
iv) comparative data on national information policy-making;

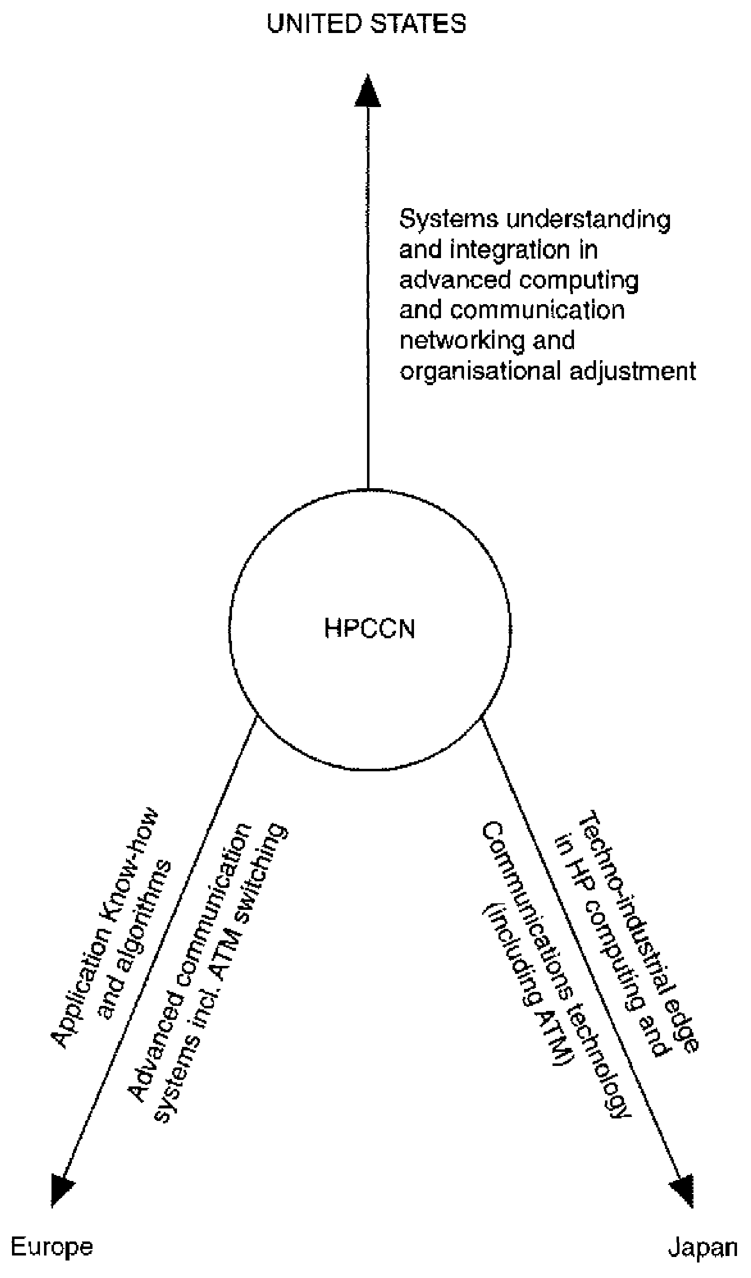
v) longer-term technical trends in data communications technology;

vi) a comparison of major national efforts in advanced data communications;

vii) a comparative international survey of existing case studies (both formal published research, and unpublished reports) of the determinants of diffusion and usage of emerging and experimental advanced computer and communications applications.

Figure 6

COMPARATIVE ADVANTAGES AND DEVELOPMENT TRENDS IN HPCCN BY COUNTRIES



Chapter 4: A Draft International HPCC Research Agenda

The lessons that emerged from the project include:

-- high performance computing-communication networks are important and make a significant contribution to the performance of OECD regions;

-- there is a close relationship between applications and use, on the one hand, and technical and economic choices in network design, on the other;

-- high performance computer and communication networks are more costly than traditional, lower performing data transmission networks, and it has only been users with the most demanding applications who, at this stage, have been able to justify investments in leading edge technologies.

In addition, there appears to be a general consensus in the three OECD regions that their information-communications infrastructure need to be substantially improved. However, there is much less agreement on the details, both within and among the national governments. Opinions differ on the desirable characteristics of the architecture of the new systems, the speed with which they should be installed, and the proper investment strategies. By and large, solid data and analyses that would help guide such decisions are lacking.

For this reason, many experts have turned to smaller, more focused HPCC programmes targeted at developing high-end communications systems in support of research and education. These programmes pursue basically three goals:

-- to serve as experimental platforms for developing new telecommunications technologies;

-- to provide advanced communications services to an important constituency, research and education, that will benefit immediately from access; and

-- to serve as a test bed and nursery for developing new applications and for gaining insight into key policy issues that will be raised by eventual new national infrastructures (examples are packet switching, e-mail and Gopher).

Not all questions will be answered by these HPCC experimental testbeds. Compared with a national system, they are small. They serve a narrow, specialised community and patterns of government subsidies may distort curtain aspects of their use.

None the less, these experiments should provide important insights to policy-makers, communications managers and users who must eventually make key decisions about infrastructure developments. The following is a list of key questions to be comparatively examined in an on-going study of national HPCC programmes.

4.1 Network cost/performance tradeoffs

Whether to invest a hypothetical US$ 500 in an ISDN connection supporting 144 kbps, or US$ 1 000 in an ADSL link supporting 1.5 Mbps, or US$ 20 000 in a fibre connection supporting a 600 Mbps bit rate, is inextricably linked to what sorts of applications will be employing the available bandwidth (and the pricing of these applications). Economically rational network technology choices must balance the cost of different levels of performance with the value of services likely to become feasible (and to generate significant demand, at some price).

Another strategic question concerns the possibilities to reduce costs in HPCC and traditional communication services through investment in new transmission and switching facilities. The model developed in the footnote presents a hypothetical corridor of the reductions that might be yielded through investment in advanced network technology in a competitive environment.

4.2 Technology trends: cost and functionality

Although for many years, communication technologies (principally telephony) moved forward only gradually, recent years have seen a rapid acceleration in innovation in terms of transmission rates, system intelligence, and new applications. As a result, functionality is increasing and costs are dropping. This high pace of innovation, spurred by advances in microelectronics, materials, and information systems, will continue for the foreseeable future, and it can greatly complicate the decision process for infrastructure investment.

In particular, policy makers face two dilemmas:

-- When and how should the infrastructure investment decisions be made, given that those decisions can "freeze" technology by locking long-term investment into specific forms of technology?

-- What models of demand should those decisions be based on, given that applications and end user needs are changing so quickly, and that infrastructure deployment takes decades? How can those models be developed and verified to the point where major investment decisions can be justified?

4.3 Economics of demand for new applications

At all sites visited, considerable effort was being devoted to the development and testing of new applications requiring the bandwidths available on high performance computing and communications systems. The economic viability of high performance communications systems is intimately linked to the demand for applications requiring these communications capabilities. Forecasts of demand for new applications can at best build on knowledge about the contours of demand for existing, related applications. All too often, however, there is virtually no serious literature examining such basic issues as the determinants of demand and diffusion (price, income, etc.) for existing services, much as video programming, voice conferencing, database services, and other computer and communications-based services. Indeed, even simple questions about the price and income elasticity of voice services demand, for example, cannot be answered easily, and even educated guesses about determinants of demand for such newer services as data communications and computerised data bases are lacking.

Improving our empirical knowledge base about the economics of demand for existing video, voice, and information services would seem essential in arriving at informed decisions -- public and private -- about choices in network design and deployment. Given the large investments contemplated in building next-generation networks (in the United States, estimates run into the hundreds of billions of dollars), the economic pay-off to a well-considered public policy may seem obvious. Research on the economics of demand for advanced information services should be a priority.

4.4 Economic impact of applications

A related issue is the degree to which we understand the returns on investments in communications networks. Given the potentially huge costs involved, evaluations of economic returns to such large scale network investments, and the technical and economic tradeoffs which may be involved in planning such projects, should build on a solid empirical foundation. Improving basic knowledge about the economic returns -- social and private -- and economic choices embedded in such investments may be an important element in rationalising such expenditures. Two elements deserve study.

4.4.1 Productivity

Investment in improved communications presumably is justified by returns to communications user industries in the form of improved productivity in the use of other resources. Studies to date on the economy-wide pay-offs to improved communications services are relatively primitive. Informed policy choices require considerably better information on the likely productivity benefits flowing from such investments.

4.4.2 Industrial organisation -- information access and competition

Equitable access to the information infrastructure and many of the information resources on it is necessary for effective economic competition. At same time, information and information technology are basic resources that allow firms to customise their products and compete.

Nations will be defining access rules that draw the lines between public and private information resources through policy and laws on antitrust, intellectual property, and public access. National policies are likely to interact in a complex way, differentially affecting the competitiveness of firms based in different regions. Dealing with conflicts rising from these interactions, and understanding their impact on the competitive fortunes of U.S. firms, is likely to be an increasingly important issue for U.S. policy-makers.

4.5 International connectivity

As nations undertake development of their network infrastructure, connectivity between national systems is likely to become an increasingly important issue. For example, in the United States there are currently at least two different, and incompatible, standards for low speed video telephony. In Japan there are at least three such incompatible systems currently in production. Furthermore, none of the American systems is compatible with any of the Japanese systems. The issue of creating a common national standard must clearly be faced. Only a little further down the line, the even more complex issue of international harmonisation of national standards must also be confronted. It will clearly be beneficial to all to maintain some minimal level of compatibility between national standards for new services. Creating mechanisms which deal with this problem effectively is an important priority for international organisations.

4.6 Social/political policy issues

Information policy issues raised by an advanced information infrastructure include freedom of expression, intellectual property, access, privacy and confidentiality, the security/integrity/reliability of data resources, and archiving of data resources. Information policy arises from a difficult process of striking balances among conflicting social interests, and most issues have roots that are centuries old. Technological change can alter prior balances that have been struck, or create new types of resources and services for which no existing models or rules necessarily apply. How nations resolve these issues will significantly affect information flows over the infrastructure.

4.6.1 Freedom of expression

This issue boils down to three basic elements:

-- the ability to access information. To what extent should policy assure broad, equitable public right to have access to the basic information streams in society?

-- the ability to preserve confidentiality of access. To what extent can and should policy protect a user's ability to access information without the intervention of government, employer, or any other interested party; and

-- the ability to express ideas. If the main locus of public discourse is moving to the electronic arena, some opportunity to speak on those new media will be central to free expression. The electronic media, though commonly thought of as democratising, can also provide new potential gatekeepers and control points for expression. Democratic governments will be expected to protect speech over the new media.

4.6.2 Privacy

The information infrastructure generates significant new threats to the privacy of individuals and organisations, whether they use the facilities directly or not. More information is collected about people and their activities, and it can be more easily accessed and merged over the network. Since it is in electronic form, it can much more readily be searched, compared, analysed, and exchanged. Pressures to gain access continue to grow: for example, on government to investigate crime or provide benefits or private sector users looking for credit information or employment histories. Many governments are being asked to strike a balance between the needs of their own agencies to collect and use information on citizens and the privacy rights of those citizens. They are also under pressure to limit or control the use of personal information by private organisations.

4.6.3 Security

Security entails ensuring both the safety of the physical network and also the integrity and reliability of the resources available on it. The network makes the security problem especially difficult in two ways:

-- it expands accessibility, increasing by many orders of magnitude the numbers and geographical distribution of individuals able to access information resources; and

-- in many applications, the ability to manipulate information is a fundamental element of the service, but it also poses questions regarding the ability to change data, thus potentially challenging the reliability and integrity of the database.

Policy and law (including criminal sanctions), administrative policies and procedures, and technological solutions will all be drawn on to preserve the integrity of network-based information resources. However, once again, balance will need to be maintained between the need to protect assets and the desire to realise the full benefits of a universally accessible infrastructure.

4.6.4 Intellectual property

The extraordinary growth and use of networks in such a short time has placed new pressures on the intellectual property system, which will undoubtedly require significant revision in the future. The ease with which one can make digital copies of an article or data file is the chief concern. The vision of the digital library with access to the content of resources without regard for location and form, fuels a sense in some that there is an immediate need for a recasting or rethinking of some intellectual property law.

There is a broad public consensus among users and publishers that governments should continue to protect copyrighted materials. At the same time, free flow of information and innovation can be chilled by overly strict protection policies. Intellectual property law is, in its essence, a balance between granting limited monopoly rights to creators and distributors and providing public rights to access, exchange, and use information.

4.6.5 Access

Access has two components -- access to the network and access to resources on the network. Clearly, access to the network itself, needs to be as open as possible since it is the pathway to any available resources on the network. Just as clearly, the resources will have a variety of rules regarding access, depending on privacy, intellectual property, national security and other considerations. It will be the government's job, however, to see that the network operates under a presumption that it be as open and accessible as possible and to support equitable access.

4.6.6 Archiving

As recent court decisions in the U.S. show, rules regarding archiving of electronic information continue to be in great flux. This issue is of particular interest to scholars, for whom preserving historical archives of research materials is of critical importance. Yet, nations may already be losing important records: historical records that are being erased in the name of efficiency and scientific data stored in conditions of decay. Protecting and archiving these data should be an important concern of government.

PART II: HPCC BACKGROUND REPORT

Chapter 5: Cross-country Analysis on the State of the Art on HPCC Developments and Applications

5.1 Development trends in High Performance Computing (HPC)[30]

5.1.1 Introduction

High performance computing (HPC) components of national and international programmes must always be viewed against the other components of these programmes, such as high speed networking, basic research in algorithms, applications developments and educational issues that form their broader background.

5.1.2 Technical background

HPC has been dominated since the development of the first Cray computer in the mid-1970s by vector processing technology. These are machines, traditionally known as supercomputers, especially designed to compute operations on long vectors of floating point numbers in a pipe-lined fashion.

These computations are fundamental to many areas of science. The development of vector processor supercomputers revolutionised how science was done in many of these areas. The impact was so great that the Nobel Laureate, Kenneth Wilson from Cornell, made his famous assertion that the two classical scientific paradigms of theory and experiment would soon be joined by a third - computation, where the supercomputer would allow experiments to be carried out totally within the computer and where physical experimentation would not be required. This would allow, for example, the development of the computational wind tunnel where new aircraft designs could be tested without the huge expense of constructing physical models.

Vector processing supercomputers were increasing in speed by almost a factor of two every year. Although this prodigious increase was being greedily devoured by the users of this technology, more speed was still needed. Some speed increase was obtained by going to multiprocessor configurations, with perhaps 16 processors sharing a single shared memory space, and by substantial algorithmic improvements.

However, it became clear in the late 1980s that this continuing speed increase (basically resulting from the continuing speed increase of the central processing units -- CPUs -- in such machines) could not be sustained much longer since the technology was starting to approach physical limits in CPU size, communications and heat dissipation. Consequently, serious attention began to be focused on parallel computing architectures as a way of continuing to deliver the performance increases that science was demanding. Parallel computers involve hundreds or even thousands of interconnected processors working simultaneously on a problem.

At first the design of parallel supercomputers followed a completely different direction from that of vector processing supercomputers -- most famously perhaps in the case of the CM-2 of the Thinking Machines Corporation. This used a Single Instruction Multiple Data (SIMD) architecture containing up to 64 000 very small processors. A long debate raged as to which would be the best parallel architecture to supersede vector processing architectures.

Nevertheless, one of the most significant developments in HPC is that nearly all architectures -- vector and parallel -- seem to have begun to converge into hybrid vector/Multiple Instruction Multiple Data (MIMD) machines. These are machines that typically have between 100 and 1 000 autonomous processors, each with its own memory and each incorporating a vector processor.

Nearly all supercomputer vendors are either producing products of this kind (Thinking Machines Corporation CM-5; Intel Paragon; Kendall Square Research KSR 1; Fujitsu AP-1000) or have announced them (IBM Envoy -- since renamed; Fujitsu VPP-500; Cray Research Inc. MPP and Triton nCube 3).

However, the convergence of supercomputer architectures into vector/MIMD hybrids does not mean that unanimity now reigns in this field. At the next level down of technical detail a vigorous debate still rages as to what is the best kind of vector/MIMD hybrid. This debate encompasses issues such as whether it is better to have a smaller number of processors with larger vector co-processors (e.g. VPP-500) or a larger number of processors with smaller vector co-processors (e.g. CM-5); and issues such as the topology of the interconnection between the processors and whether the machine should have a distributed memory programming model (e.g. CM-5) or a shared memory model (e.g. KSR 1).

Nevertheless, the vector/MIMD hybrid seems likely to dominate HPC for much of the rest of this decade, assuming the very difficult and challenging software problems are adequately solved.

5.1.3 The grand challenges

Reflecting on many of the fields where development had been significantly affected by supercomputing, a number of insightful scientists also noticed that in many cases the use of supercomputers had only scratched the surface of the kinds of problems whose solution could have a dramatic effect in the relevant field. For example, in the case of aerodynamics, though the aerodynamic characteristics of various parts of an aircraft structure could be studied in real-time using supercomputers, the study of whole aircraft designs this way, using the supercomputer as a computational wind tunnel, was beyond even the most powerful machine. To do this, supercomputers with speeds of thousands of times those of the fastest in existence would be needed. But the study of aircraft designs this way could lead to the elimination of both wind tunnels and also the construction of extremely expensive prototypes. The goal has been attributed to Boeing of wanting to design its next generation of aircraft totally using supercomputers without any prototypes or wind tunnel testing. Clearly the economic consequences of being able to do so would be enormous.

The task of doing this became known as a Grand Challenge. Comparable Grand Challenges were identified in many other fields, such as combustion systems, computational chemistry, ocean science, pharmaceutical design, economic modelling, improved oil and gas recovery, molecular biology, materials science, nuclear fusion reactor design and simulation, climate modelling, semiconductor design, structural engineering, superconductivity, resource and environmental modelling.

The characteristics of Grand Challenge problems are that their solution require computers capable of speeds of at least one teraflop (= one trillion floating point operations per second), amounts of main memory in excess of one terabyte (= one million megabytes, one megabyte = one million bytes), and vast amounts of back up storage, as well as an extensive high speed communications infrastructure. In comparison, well-balanced supercomputers today rarely have a peak speed in excess of ten gigaflops. It is claimed that the solution to these problems will lead to a major increase in scientific or industrial competitiveness in these areas and to an enhanced ability to manage natural resources and environmental change.

5.1.4 The American HPCC programme

The part of the US-HPCC programme concerned with the development of computers capable of tackling Grand Challenge problems is called the High Performance Computing Systems (HPCS) component. It accounts for about 25 per cent of the programme budget.

The goal of the HPCS component is quite explicitly the construction of high performance computers capable of teraflop levels of performance by around 1995/96.

Many of the American supercomputer companies expected eventually to build machines of this speed by around the end of the decade given the evolution of technology and given that, by then, though expensive, they would be available at a price that the market could bear.

However, the HPCC programme will provide funding that will allow such machines to be built years ahead of what could have been regarded as the natural point at which they would have come to market.

The argument for the early development and introduction of teraflop technology is that it will lead to the solution of Grand Challenge problems well before they are solved elsewhere, which will in turn lead to a major competitive advantage for American science and industry in the large number of areas of economic importance to which these problems are central. Viewed this way the HPCC programme is a technology acceleration programme.

Because of the expected cost of teraflop supercomputers, one very significant development has been loosely-based consortia to acquire precursors to these machines by around 1995/96.

The model for a consortium consists of a lead research institution or institutions (usually a major university or national laboratory) and a vendor. The lead institution(s) agree to work on some major portion of the systems and applications software for the teraflop supercomputer in areas where they have expertise, together with the software vendor and hardware design teams. In turn, the vendor agrees to provide successive generations of hardware for the teraflop machine at highly discounted prices. The major share of the cost of these machines is provided by one of the HPCC partner agencies, usually the Defence Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), the National Aeronautics Space Administration (NASA) or the National Science Foundation (NSF). The consortium may also contain, as supporting members, a large number of institutions and companies who have specific Grand Challenge applications.

The motivation of the vendors in joining these consortia is to work collaboratively with world-class research organisations with outstanding experience and expertise in the development of tools and applications for parallel computers. Kenneth Wilson has drawn attention to how a crisis exists in parallel computing as (comparatively) little software exists for such machines. The vendors simply do not have the resources to meet the demand for software for parallel computers, and the problems that must be solved to produce robust, stable, efficient, portable software are extremely difficult and complex. The motivation of the research institution in joining these consortia is to become an intimate part of the hardware/software design cycle for a new generation of highly advanced computers, and to allow the development and use of applications software in highly competitive areas of science.

Examples of such consortia are those involving Oak Ridge National Laboratory and Intel, and Thinking Machines Corporation and Los Alamos National Laboratory (LANL). A consortium involving Cray Research Inc. and both LANL and Lawrence Livermore National Laboratory (LLNL) was announced late in 1992 but was withdrawn earlier this year, seemingly for political reasons. It is expected that IBM will soon form a consortium with Argonne National Laboratory. It can be expected that, provided HPCC funding remains available for consortia over the next few years, the other American computer vendors with aspirations in this area (Convex Computer Corporation, Kendall Square Research, nCube, Cray Computer Corporation, and maybe Digital Equipment Corporation) can also be expected to form consortia, though the survival of some of the smaller among them, in a highly competitive though small market, must be in doubt.

The original model for the consortium is the very successful and path-breaking Concurrent Supercomputing Consortium (CSC), whose lead institution is the California Institute of Technology and whose vendor partner is the Intel Corporation's Supercomputer Systems Division. It also has as supporting partners NASA's Jet Propulsion Laboratory, Argonne National Laboratory, Pacific Northwest Laboratory, the Centre for Research on Parallel Computation, DARPA, NASA, NSF, LLNL, Purdue University and Sandia National Laboratory. The CSC was responsible for the building by Intel of the one-off Intel Delta parallel supercomputer, which was for most of 1991 and 1992 the world's fastest computer.

5.1.5 HPCC in Europe

The definitive document on HPCC in Europe is the Rubbia Report recently presented to the Commission of the European Communities (CEC). In summary, it proposes that a 10-year European HPCCN program should be initiated, with a total investment from "public and private, national and European sources, including the CEC" rising to about one billion European Currency Units (ECUs) per year. Therefore, if implemented, the European HPCCN would be comparable in size to, and possibly considerably larger than, the American HPCC programme.

The major challenge (and possibly the major opportunity) in HPC facing Europe, is the lack of a major industrial base in this area. The development of the transputer by a number of CEC programmes still has to be tested in real applications (in particular embedded applications of HPCC). At this stage, HPC installations in Europe are dominated by machines from American and Japanese vendors, though it is worth noting that Europe is an "early adopter and user" of HPC.

In a development that may be suggestive of the future of the HPCC industry in Europe, Meiko has released a recent high performance parallel computer which incorporates Fujitsu vector co-processor chips.

However, the Rubbia Report suggests that Europe should develop its own viable HPCC industry. The lack of a major industrial base in this area is seen as a possible advantage and the report argues that Europe is free to concentrate on building an industrial base in what is the fastest growing segment of the HPCC market -- the market for high performance parallel systems. This is the only HPCC area where Europe already has some significant industrial capacity and where it also has outstanding skills in basic research and applications. This is an extremely ambitious goal, but probably the only viable alternative to becoming a market totally dominated by American and Japanese HPC systems.

The Rubbia Report also recommends the formation of "support nodes" with a strong focus on industrial applications. These nodes seem similar to the kinds of consortia now forming in America. In fact, the Regional Computing Centre at the University of Stuttgart -- which the OECD expert group visited -- might be a model for such modes, in particular as it focuses on the development of innovative solutions to strengthen the competitive position of the surrounding industry. There appears to be an expectation that these consortia would be multinational in membership. The main impediment to these consortia functioning properly in a multilateral way (which is probably essential for them to be competitive with the American consortia) seems to be problems with networking between member countries of the EC.

5.1.6 High Performance Computing (HPC) in the Asia/Pacific region

There is at present no HPCC program in the Asia/Pacific region comparable with the American HPCC programme or with that proposed in the Rubbia Report for Europe. Scientists in countries in the region watch developments in Europe and America in this area with some apprehension as they have some concern that they will be left behind by these technology acceleration programmes. There is considerable interest in regional initiatives in this area.

Japan is the dominant technological power in the region and the only one presently capable of competing with America in HPCC. Japan's Ministry of International Trade and Industry (MITI) has had a history of strong support for the development of Japan's information technology industry. However, by the late 1970s it was felt that this industry was now well-developed and capable of competing effectively nationally and internationally.

MITI's attention then turned to the development of new national programmes in information technology that would, through technology transfer from the programmes to the companies, allow the industry, not just to compete on equal terms internationally, but rather to leap-frog its present state of development and to take a dominant lead by creating a new generation of computing systems. To this extent MITI's national programmes in information technology are still technology acceleration programmes, though now more long-term and higher risk.

Its best known program (though not its only one) in advanced information technology over the last decade is that of the Institute for New Generation Computing Technology (ICOT), which ran for 10 years and which has recently been extended by two years to conclude in early 1995. Its mission in its remaining two years is to disseminate internationally to the public domain the considerable amount of software it has developed over its lifetime.

ICOT's goal, in brief, was the creation of knowledge-based computing, a goal to which it made many significant contributions.

MITI's most recent project in this area is the Real World Computing Partnership (RWCP), which formally commenced in June 1992. Its Tsukuba Research Centre opened in October 1992. The RWCP continues MITI's recent history of long-term/high-risk projects aimed at leap-frogging present developments to create dominant computing technologies of the future. MITI views it as an international research programme involving Japanese and international IT researchers and manufacturers. Apart from research undertaken at Tsukuba, there is provision for the establishment of Distributed Research Laboratories in the member organisations or outside Japan. The total RWCP budget is expected to be approximately 60 billion yen (approximately US$ 500 million) over 10 years.

Current RWCP partners in Japan include Fujitsu, Hitachi, the Japan Iron and Steel Federation, Matsushita, Mitsubishi, NEC, NTT, Oki Electric, Sanyo, Sharp, Sumitomo Electric and Toshiba, all manufacturers of computer equipment rather than users. The international partners include Germany (*viz*. GMD), the Netherlands and Sweden. The RWCP has a special arrangement with the United States involving optical computing.

The ten-year research schedule is divided into two parts. The first half consists of the formulation and extension of existing theories and models, particularly in the area it calls soft logic, and the second half will focus on integrating the results of the first half in such areas as massively parallel systems, optical computing, neural systems, theoretical foundations, and novel application functions in pursuit of "flexible computing".

An interesting feature of the RWCP is that, although it has made it clear that it is not a HPCC programme in the American or European sense, a significant portion of its budget will go towards the development of two high performance computers. The first is planned to have a peak speed of hundreds of gigaflops and the second, due to be built in the late 1990s with the expectation of considerable industry support, is expected to be a multi-teraflop machine. These machines will draw heavily on the research done at MITI's Electrotechnical Laboratory at Tsukuba on high performance data-flow computer architectures. Nevertheless, the target applications for these machines are not in general the classic Grand Challenge problems, but rather problems more characteristic of classic AI.

As noted then, the RWCP and ICOT are different kinds of programmes from the HPCC programmes in America and from that projected for Europe. At the moment, Japan does not appear to have a national programme similar to these. In fact, there is considerable debate in Japan at the moment as to whether Japan should initiate such a programme. The commitment in the package of economic measures announced by the Japanese Government in April 1993, to acquire a large number of supercomputer systems as well as other developments, could provide the opportunity for Japan to do so. There also appears to be the opportunity for Japan to take a position of regional leadership in HPCC, given that it will be difficult for any other country in the region on its own to create an internationally competitive HPCC programme.

5.1.7 Implications of HPCC programmes

The situation concerning HPCC programmes can be summarised as follows: America has one, the CEC has a strong recommendation in front of it to establish one, and Japan is considering its position.

A basic feature of HPCC programmes is the formation of consortia nationally (in the case of America) and possibly internationally (in the case of Europe) of research organisations and computer vendors to acquire HPC systems (sometimes leading to teraflop systems) normally beyond the reach of any one organisations or even of small countries.

Researchers in many smaller countries are concerned that areas of science and industry in their countries reliant on HPCC technology will be left behind by the technology acceleration provided by the HPCC programmes. So far it is not clear that other countries in the world will always be welcome to join these programmes or, more importantly, that it is in their interest to do so. In many cases, the formation of regional HPCC initiatives may well be the best way for these countries to maximise their benefits from HPCC technology. These consortia tend to be the engine rooms of HPCC programmes and it is at this level that most research organisations or countries will want to ensure their involvement is maximally beneficial.

A topic worth more detailed investigation is what impediments exist to the formation of new HPCC programmes and what barriers exist to new countries participating significantly in existing or planned programmes. Additional issues to be addressed in this context, include:

-- how and how much are these programmes able to influence the penetration of HPC in various fields: industry, society, research and so on?;

-- which have been the "measurable" effects of the American programme on industrial and scientific competitiveness?;

-- what is the industrial attitude to the present and future HPC programmes?; and

-- what is the industry perspective of HPC as opposed to the view expressed in these programmes?

5.2 Development trends in HP communications and computer-networking and applications

5.2.1 High performance communications

New technological developments and continuously improved cost/performance ratios in computing have altered the use to which computers are put. Simple number crunching batch and interactive applications based on data transmission have been replaced by more sophisticated applications. These involve comprehensive information processing for the discovery of innovative solutions for research and for industrial and social problems, all nurturing continuously increasing demand for more and enhanced computer capacities.

The high costs of HPCC, however, limit the broader diffusion of these systems. In particular small and medium-sized enterprises (SMEs), the majority of the firms in OECD’s Member countries cannot yet exploit the enabling potential of these new IT-based tools.

The costs (for individual users) involved in the typical LAN architecture of HPCC -- including the CPU, main memory and external mass storage facilities -- could decrease as HPCC is shared among a large number of users. The economies of scale to be yielded through MAN and WAN based HPCC-configurations, are, however, currently consumed by the prevailing telecommunications tariffs and charges, or are not realised because of technical bottlenecks in bandwidth and switching of existing networks. European users are particularly penalised by high telecommunications tariffs and monopolistic market structures delaying the introduction and usage of HPCC.

In all three regions of the OECD, efforts are underway to develop advanced telecommunications and HPCC related technologies. The objectives are to raise the levels of telecommunication networks -- the infrastructure of HPCC -- in terms of quality, capacity, speed, flexibility and prices to those of high performance computing.

From the site visits, it became clear that research and experiments are directed towards removing these bottlenecks in three directions:

-- *first*, through upgrading the performance of ordinary analogue telephone circuits (ISDN strategy);

-- *second*, by integrating different hierarchies of networks, including telephony, cable TV, and video networks; and

-- *third*, by developing and implementing fully digital switched flexible broadband networks (bandwidth à la carte) and transmission speeds in the gigabit range (broadband-ISDN strategy).

The last strategy is the really innovative approach and an international race has started to establish an industrial research and production base in this field. The key to providing the functions required in the high speed network approach is, on the technical side, ATMs (Asynchronous Transfer Mode) and, on the economic side, it is competition, to make sure that the new system is deployed in time on the market. ATM results from a number of technological achievements, including optical fibre cables and progress in LSI technology. With the introduction of optical fibre into communications networks, transmission errors diminish. This enables the transport network to dedicate itself entirely to information transfer by delegating most flow and error control to the terminal or a computer. Advances in VLSI technology enable systems to process protocols and perform switching economically and automatically without software control. In ATM networks, digitised voice, data, and video signals are divided into pre-defined 53-byte blocks (cells). The system gives each cell a header with a destination. While the cells resemble conventional packets, the fixed length simplifies the protocol so transmission can take place on a hardware, rather than a software basis.[31] Hence, computer communication convergence is finally accomplished with storage, processing, switching and transmission as integrated functions in a fully digital environment.

High performance communication designed around ATM and optical fibre networks permits *more than new computer-supported applications and services. It also promises to revolutionise traditional voice, data and video communications and their integration.*

The site visits focused mainly on advanced communications systems and applications designed around the use of advanced computer systems. The following section considers some of the different approaches currently being developed in the countries visited.

5.3 International comparisons of emerging trends

One clear lesson from this study was that, in each of the regions, markedly different approaches to enhancing advanced computer-communications infrastructure are pursued.

5.3.1 Japan

In Japan, technical improvement in the national communications network has to date focused on the accelerated introduction of narrowband ISDN (integrated services digital network) services. First introduced in 1988, ISDN services in Japan have been promoted with aggressive investments by NTT (Nippon Telegraph and Telephone). By March 1992, there were approximately 84 thousand basic rate ISDN access lines in service in Japan, as well as almost 1.8 thousand primary rate access lines. At the time of the site visit in July 1992, well over 90 000 basic rate access lines had been installed. Particularly notable was the installation of over 2 800 ISDN-capable public telephones over this period. In the fiscal year ending in March 1992, over 170 million ISDN telephone calls were made (in 64 Kbps circuit-switched mode), compared with 73.5 billion conventional voice calls made over the public switched telephone network.

The development of an Internet-style TCP/IP network[32] infrastructure started in 1987 and IP services were started in 1992. At this stage, the implementation and usage of IP networks in Japan has followed quite different diffusion patterns as the attached tables reveal. The multitude of corporate networks, PC and operating systems seems to have delayed networking. With a view to rapidly establishing a nation-wide IP network, the Science Technology Agency (STA), MITI, MPT and the Ministry of Education are planning to jointly support this development. For the business community, AT&T and JENS (Japanese Electronic Network Services, a Special-type II carrier) provide domestic and international value-added services.

Similar to the USA and Europe, regulatory structures in Japan seem to be playing a critical role in the evolution of the network. The key player is NTT, now a private corporation. In the meeting with senior members of the management of MPT, the research team was informed about a comprehensive programme of investment in broadband ISDN to provide services to all business and virtually all homes by the year 2015.

Co-ordination among government institutions then is playing an increasingly important role in the modernisation of the communications network infrastructure in Japan. The Ministry of International Trade and Industry (MITI) is funding some network-related investments as part of its Real World Computing (RWC) programme, mainly to provide services to advanced users involved in computer research. The Ministry of Education does have ambitious plans to connect educational institutions with an IP network. The Ministry of Posts and Telecommunications is sponsoring research at both its own Communications Research Laboratory and outside totalling about 2 billion yen in fiscal 1993. NTT, in turn, has its own agenda, increasingly driven by the realities of growing domestic competition.

With a view to bridging the different motivations among these players and ensure the continuing modernisation of Japans electronic information infrastructure, the government is planning to establish an inter-agency network. This initiative also pursues enhancing the research base in this area.

5.3.2 The United States

The evolution of high performance networking in the United States has been intimately linked with the creation of the Internet, a TCP/IP-based computer communications network that began as a pilot project -- ARPAnet -- funded by the Department of Defence. In recent years, the standards and protocols developed for that initial experiment have been further augmented and deployed as the core of a large scale network linking U.S. academic institutions, financed by the National Science Foundation. Today, the Internet is a loose collection of interconnected IP networks involving more than 2 000 000 computers, linked by a core backbone that continues to receive significant support from NSF. The Internet today connects some 3 million government and academic computer users, along with an increasing number of commercial enterprises and foreign subscribers.

One unique feature of the U.S. Internet is the manner in which it was constructed. This packet-switched communications network was created as an entity that was functionally independent of the public switched telephone network, though public communications carriers do provide private data transport services on different links within this collection of networks. Because it was conceived as effectively separate from the public switched telephone network, and primarily designed to serve a government, non-profit, and educational community, it evolved free of the regulatory and other constraints faced by the public telephone network. As a testbed for developing new communications network and application technology, it also permitted a degree of experimentation that would probably not have been available to developers working on the commercial, public switched network.

Many services first developed for experimental use on the Internet are now in increasingly wide commercial usage. It is probably fair to say that the current widespread use in the United States of ubiquitous electronic mail, file transfers among widely distributed computers, and remote log-ins to physically distant computers, owes much to the accelerated development of the Internet. New services and applications, such as packet sound, video, fast and remote retrieval of high quality text and image data (digital libraries), and distributed information servers [like the Gopher and WAIS (wide area information server)], are only the most visible edge of a whole new generation of applications that will consume the increasing amounts of bandwidth available on the Internet as it is modernised and upgraded.

Current national efforts to upgrade communications infrastructure in the United States take two distinct paths. The High Performance Computing and Communications Initiative (HPCCI), in addition to funding R&D on new computer architectures and software algorithms, puts significant resources into a National Research and Education Network, the NREN. Other resources are being invested in a number of testbed projects created to experiment with the technologies used in very high speed (gigabit) networks.

These government supported efforts focus on investment in understanding the problems and creating the basic technology required to deal with gigabit data rates, and supporting major growth in the networks linking educational and research computer users.

The second major set of initiatives involves the upgrading of the public switched telephone network. One major side effect of the deregulation of the long distance telephone market in the United States has been the entry of a significant number of new companies into this business, and the creation of a highly competitive business environment. Not only conventional long distance voice telephony, but also digital leased lines have plunged in price. A substantial cheapening of digital data bandwidth has clearly been one of the factors driving the extraordinary growth in wide area networking in the United States. At the end of 1991, for example, U.S. local exchange carriers had installed about 11 000 optical fibres carrying data at DS-3 rates (45 megabits per second) or greater, which terminated on customer premises. Generally, circuits delivering these data rates were simply unavailable commercially in Japan or Europe.

Currently, the major public communications carriers are offering a variety of new digital data transport services, including so-called fractional T-1, frame relay packet-switched services and switched multimegabit data services (SMDS). Many carriers have also now announced the introduction of services based on asynchronous transfer mode (ATM) into their networks. ATM technology allows both voice and other data to be prioritised and transmitted over a single communications system at rates exceeding a gigabit per second, and promises to be the untying technology which brings together the now separate world of Internet-style packet-switched networks with the public switched telephone network, in a single seamless, ubiquitous network.

While large businesses are already using these newer, high speed commercial data transport services, small businesses and residential consumers of telephone services cannot currently justify the costly investments needed to gain access to these services. The nature of the new applications that will justify investing in better connections, and the nature of these faster links to the public network, are now the focus of a developing public policy debate in the United States. Currently, for example, some interest groups advocate upgrading small users' connections to the network using ISDN technology (delivering a maximum of 144 kbps) over existing copper wires. Others extol the virtues of Bellcore's ADSL system (which delivers roughly 1.5 megabit per second over existing copper wires). Others argue that optical fibre (delivering hundreds of megabits at a greater cost) makes the most sense as a long term strategy.

ISDN technology is commonly thought to have been deployed much less aggressively in the United States than in Japan. A careful perusal of available data, however, suggests that this may not have been the case. There were approximately 300 000 basic rate ISDN interfaces installed within local exchange companies in the United States at the end of 1991, and more than 1 700 primary rate ISDN interfaces. On the other hand, FCC data show that there were only 67 000 switched basic rate ISDN control channels in use at that same time. Thus, more than three-quarters of the ISDN access lines in use appear to have been configured as part of private networks. These and other data suggest that ISDN in the United States has primarily been used as a relatively low speed metropolitan area network technology. The low usage of primary rate ISDN connections confirms an observation already made -- that cheap dedicated digital leased lines provide stiff competition for ISDN in the United States, and that relatively high rates of ISDN penetration overseas in part reflect the much higher digital line costs observed in Europe and Japan. The key point is that ISDN use is an economic decision that interacts strongly with the availability and cost of other digital data communications alternatives.

5.3.3 Europe

In general, the members of the OECD research team were impressed with the strong research base and impressive laboratory and demonstration projects observed in Germany. The experimental applications viewed reflected a high level of quality and innovation.

However, German and CERN network users in Switzerland complained about the high cost and the limited availability of high performance digital data transport facilities on the public (telephone) network in Europe. Basic leased data circuits, generally supplied by PTTs holding a monopoly position, are commonly supplied at up to 10 times the price of equivalent services in the USA.[33] Unlike the case in the United States, a packet-switched IP network infrastructure independent of the public telephone and telegraph (PTT) companies, has not been allowed to develop. As a consequence, though the Internet has grown rapidly in Europe in terms of nodes and connectivity, the bandwidth connecting these nodes has grown only pitifully, and high performance computer users are quick to complain about the low effective communication rates with other sites in Europe.

In February 1993, a plan for a pan-European backbone for TCP/IP and X.25 packet-switched traffic, offering speeds up to 2 megabits per second, was announced by the European Community. Though a much-needed upgrade to Europe's network infrastructure, this falls far short of the 45 megabit per second links already used on the backbone of the U.S. NREN.

The fundamental obstacle to rapid improvement in performance of the network infrastructure in Europe would appear to be the attitudes of European PTTs, who see no significant commercial market for data transport services offered at very high bit rates. Coupled with the resistance of supercomputer centres and other high performance users to paying very high tariffs for relatively limited bandwidth, this creates a chicken-and-egg problem of sorts.

One promising route for breaking this impasse appears to be visible in the United Kingdom. There, Britain's JANET (the British research equivalent of Internet) has rapidly upgraded the cross-section of its communication links at relatively low prices as some degree of competition now exists. This drives home a key point: in Europe, rapid progress in high performance networks seems intimately related to the market structure of the data communications industry, which for the most part remains firmly in the hold of monopolies.

Though Europe is frequently portrayed as more advanced than the U.S. in terms of ISDN penetration (certainly, a much larger portion of the switches installed in France, Germany, and the U.K. are ISDN capable), the reality of the usage of ISDN belies this image. At the end of 1991, there were about 20 000 basic rate access lines installed in France, less than 10 000 in Germany, and less than 3 000 in the United Kingdom. Primary rate access was more impressive, with 3 800 access lines in France, 5 600 in Germany, and over 4 500 in the U.K. But, because of the high cost of digital lines in these countries, these relatively high rates must be interpreted at least in part as a substitution phenomenon, with basic rate ISDN employed as a substitute for dedicated 56 kbps lines, and primary rate ISDN used as a substitute in applications which in the U.S. might employ a dedicated T-1 line.

Table 1. **Diffusion of INTERNET* in OECD countries**
(Number of national networks in 1993)

North America	
Canada	429
United States	5 571
Total	**6 000**
OECD Europe	
Austria	84
Belgium	14
Denmark	8
Finland	102
France	453
Germany	443
Greece	11
Iceland	13
Ireland	24
Italy	169
Luxembourg	4
Netherlands	131
Norway	52
Portugal	35
Spain	39
Sweden	87
Switzerland	87
Turkey	9
United Kingdom	420
Total	**2 172**
OECD Pacific	
Australia	189
Japan	257
New Zealand	50
Total	**496**
Total OECD	8 668

* INTERNET can be defined as a vast global open informations meta-network (a network of networks) by which computers are able to communicate with each other. In October 1993 some 2 million computers were attached to INTERNET.

Source: Compiled from Internet Society, State of the Internet; Tony Rutkowski, Sprint Group; August 1993.

Table 2. **Number of computers connected to INTERNET (October 1993)**

North America	
Canada	79 837
United States	1 413 408
Total	1 493 245
OECD Europe	
Austria	13 924
Belgium	6 265
Denmark	7 647
Finland	29 292
France	47 826
Germany	103 324
Greece	1 808
Iceland	1 499
Ireland	2 131
Italy	14 701
Luxembourg	263
Netherlands	39 940
Norway	28 322
Portugal	3 232
Spain	11 866
Sweden	37 767
Switzerland	31 488
Turkey	514
United Kingdom	100 609
Total	**482 418**
OECD Pacific	
Australia	97 840
Japan	43 697
New Zealand	4 342
Total	**145 879**
Total OECD	2 121 452

Source: Compiled from data provided by Network Information Systems Center, State of the INTERNET, in: Internet Society, Tony Rutkowski, Sprint Corporation, October 1993, United States.

Chapter 6: Country/Region Reports on HPCC sites visited and Reports on National R&D Programmes for HPCC

6.1 High performance computing and communications in Japan[34]

This chapter (prepared by Mr S. Asano) presents summary findings of the HPCC site visits in Japan and an overview of national programmes having a bearing on HPCC developments. It includes the master plan for the Real-World Computing Programme of MITI and the MPT policy to develop switched broadband networks.

6.1.1. Introduction

In Japan, HPCC related research activities are conducted at the Nippon Telegraph and Telephone Corporation (NTT), the Electro Technical Laboratory (ETL/MITI) and the National Centre for Science Information Systems (NACSIS/MESC), with governmental support by the Ministry of International Trade and Industry (MITI) and the Ministry of Education, Science and Culture (MESC), respectively. These research activities, however, are conducted independently.

Three Ministries (MPT, MITI and MESC) have their own policies for promoting HPCC research.

MPT has a telecommunications promotion and enhancement policy in which research and development on high speed computing is included. Actual research activities are identified in NTT, however, as promotion is already established through the Foundation for Promotion of New-Generation Telecommunications Network, where software and application technologies are to be developed and demonstrated with telecommunications operators, manufacturers and user industries.

MITI has been engaged in a series of projects related to the enhancement of information processing technologies, many of which are widely known. The Real World Computing (RWC) Project is financed by MITI and involves the ETL, industry and universities. Some members of the RWC project are from Europe and other parts of Asia, a result of a new developmental policy that is open to countries outside Japan. The RWC project is essentially concerned with information processing technology, while the research environment is strictly related to high performance computing and communication.

MESC has been promoting and financing academic research involving the National Centre for Science Information Systems (NACSIS). MESC is now engaged in a new programme which is promoting basic research. The HPCC related research is assigned to NACSIS and is scheduled to start in 1993 in order to complete basic developmental studies and feasibility demonstrations of HPCC for the next generation Japanese Science Information Network, which will be transformed into a future Japanese academic research network.

6.1.2 Governmental policies

6.1.2.1 Ministry of Posts and Telecommunications

General policy

The Ministry of Posts and Telecommunications (MPT) is engaged in administrative affairs related to telecommunications as well as postal services.

In order to build a healthy, more sophisticated information society, MPT is working on the establishment of an overall information policy, the promotion of better regional communications and decentralisation of information functions, the development of communications technology, and the development and use of space technology.

Arrangements for promotion of research

MPT consulted with the Telecommunications Technology Council on basic concepts and policies for the promotion of research and development for information and telecommunications technology. Based on the report of the Council MPT formulated research and development guidelines for telecommunications technology in May 1992.

These guidelines extract the subjects of research and development to be promoted for the 21st century and explain issues relating to network technology
and application technology for HPCC.

It is estimated that the following system functions are required for telecommunications development:

1) personal function;
2) private function;
3) intelligent function;
4) visual function;
5) multimedia function;
6) global networking function;
7) high speed and large capacity transfer function;
8) open function;
9) reliability function.

Arrangements for the promotion of the new communications network

a) What is the new generation telecommunications network?

The New Generation Telecommunications Network is an enhanced network for the 21st century. In this network, B-ISDN (Broadband ISDN) and IN (Intelligent Network) are considered essential parts.

In recent years, Japanese society has been experiencing rapid changes due to the increasing use of advanced info-communications systems, which have also helped Japanese economic growth. At the same time, the customer's requirements for telecommunications services have become more diverse and sophisticated.

Recognising such circumstances, the MPT has started a new project aimed at replacing the existing network (which had been configured mainly for analogue telephone networks) with a new network which can fulfil future needs. The concept of the New Generation Telecommunications Network was established for this project.

b) Construction of the new generation telecommunications network in japan

The MPT will play a central role in promoting the construction of the New Generation Telecommunication Network in Japan. The MPT will take various measures to promote this new network, such as giving financial support authorised by the Law for Enhancement of Telecommunications Infrastructure.

The private sector, which includes NTT (Nippon Telegraph and Telephone Corporation), has been taking an important part in R&D work on B-ISDN.

c) The law for enhancement of telecommunications infrastructure

MPT conducts the following support measures for the promotion of the construction of the New Generation Telecommunications Network, including B-ISDN, by telecommunications carriers in accordance with the Law for Enhancement of Telecommunications Infrastructure, enforced on 1 June 1991:

-- facilities to be supported: SDH transmission equipment, optical fibre cable, service control facilities, information media conversion equipment, ATM switch; and

-- measures of support: specially recognised depreciation, special abatement for municipal property tax, lower interest government loans and loans without interest through the Japan Development Bank.

Other support for the new generation telecommunications network

It is necessary for the smooth introduction of the New Generation Telecommunications Network to expand governmental support further, in addition to the current measures of the law.

Presently the following are adopted:

i) establishment of a Foundation for the Promotion of the New Generation Telecommunications Network

-- It is also important to encourage R&D on software -- as opposed to hardware -- technologies and systems for the new network. The Association for the Promotion of New Generation Network Services was established by the private sector on 1 April 1992. Its purpose is to study various aspects of New Generation Telecommunications Network, including pre-operational tests of the systems, development of the applications, and feasibility studies of the services.

-- Telecommunications carriers, such as NTT and KDD, telecommunications equipment manufactures, and a wide range of users from broadcasting companies to financial companies, participate in this Foundation. Its activities are expected to contribute greatly to the smooth introduction of the New Generation Telecommunications Network.

ii) support for facilities for R&D on broadband telecommunications technology

-- The government gives financial support to the private sector to construct facilities for R&D on telecommunications technology, systems for the new network.

Policy on introduction of B-ISDN

a) Results of research and study regarding construction of B-ISDN

MPT established a group consisting of telecommunications carriers, vendors, users, etc., and conducted research and study on the image of B-ISDN utilisation, demand for B-ISDN, social and economic propagation effects, and the possibility for realisation of B-ISDN from various points of view, with the understanding that B-ISDN will become part of the telecommunications infrastructure of the 21st century, and that it is necessary to promote the development and introduction of B-ISDN. The group reported in April 1992.

According to the report, the projected diffusion level of B-ISDN to offices and households in 2015 will be 77 per burden on running businesses and government support will be necessary. *It is necessary to conduct social experiments since it is not clear what promising forms of utilisation justify such investment.*

b) Support measures for the introduction of B-ISDN

B-ISDN services have not yet started in Japan and efforts are concentrated on the development of new technology.

For the introduction and diffusion of B-ISDN, the construction of an excellent network and the development of useful applications that can arouse demand will be necessary.

Therefore, the above support measures for the promotion of the construction of New Generation Telecommunications Network are applied to the construction of B-ISDN.

The Association for the Promotion of New Generation Network Services promotes the experiments on B-ISDN, the development of applications, etc. Preparation for the implementation of field tests for B-ISDN is now proceeding.

6.1.2.2 Ministry of International Trade and Industry (MITI)

General policy

The major goals of MITI's policies on information technologies are generally presented under the heading "informatisation". This means that MITI encourages the use of information systems to their fullest extent.

The major implementation measures of MITI's informatisation policies are summarised in the following sections.

The promotion of open systems

a) Promotion of Open Systems Integration (OSI)

-- promotion of standardisation for inter-operability of computer systems;
-- development of OSI profiles;
-- low interest loans and tax reductions for computer systems based on OSI.

b) Promotion of EDI

-- inter-industrial EDI pilot model development project;
-- low interest loans for EDI systems based on standard business protocols (e.g. CII[35] standard, EDIFACT, etc.);

c) Research, development and evaluation of open middle-ware technology.

The promotion of pre-competitive IT R&D on an international basis

1. The fifth generation computer projects;
2. Real World Computer programmes;
3. R&D project on the ultimate manipulation of atoms and molecules;
4. Development of bioelectronic devices;
5. Development of superconductive materials and devices;
6. Development of new structures for software development.

Enhancement of information processing functions in cities and less developed regions:

-- New Media Community programmes for informatisation of less developed regions;
-- Advanced Information City programmes for the informatisation of cities;
-- Promotion programme for Information Centres in the Commercial District;

- -- High-Vision (HDTV) Community programmes to build information networks and to reactivate the local economy and culture;
- -- Programmes for the enhancement of software productivity in less developed regions.

The promotion of video information systems

1. Research on multimedia networks;
2. Research on computer systems for processing high-definition video data.

Development of information systems for personal use, especially for senior citizens

1. The Mellow Society Project -- development of human-machine interfaces for senior citizens and filing systems for personal data for health purposes.

2. FRIEND 21 Project -- development of technologies for user-friendly information systems.

The development of infrastructure for the "Information Society"

1. Promotion of computer network security;
2. Development of human resources.

International co-operation in IT development with developing countries

1. Development of automatic translation systems (Japanese, Chinese, Thai, Indonesian);
2. Collaboration with Singapore in the development of computer-aided instruction systems for information processing technology.

Formulation of rules for the protection of intellectual property rights

6.1.2.3 The Ministry of Education Science and Culture (MESC)

In 1953, the Science Council of Japan recommended that the Ministry of Education, Science and Culture (MESC) establish a joint facility to provide large scale computer resources for academic research in Japan. This led to the establishment of the National Academic Computing Service of Japan.

In 1966, the University of Tokyo opened its computing facility. The other six centres -- Hokkaido University, Tohoku University, Nagoya University, Kyoto University, Osaka University and Kyushu University -- had started services by 1971.

The National Centre for Science Information Systems (NACSIS) of MESC was inaugurated in April 1986 as the central institute for providing infrastructure for academic research in Japan. NACSIS is one of the Inter-university Research Institutes which serves all university researchers in Japan. Its particular function is to gather, organise and provide scholarly information, as well as to carry out research and development.

During 1991, online shared cataloguing activities substantially expanded. By the end of the fiscal year, the number of university libraries connected online to NACSIS amounted to 190, the total number of catalogue terminals exceeded 1700, and the number of transactions reached 6.7 million. Updating of the union catalogue for Japanese periodicals was completed in 1991. 700 university libraries participated in collecting 70 000 titles and 1.5 million holdings. Updating of the union catalogue for foreign periodicals started in 1992.

Currently, more than 40 large databases are in service. Construction has continued on 18 databases started earlier, and a new service will be started in 1992 for databases constructed by university researchers.

Since 1986, NACSIS has been conducting network development. By installing 28 nodal packet switches, 460 computers or networks belonging to 180 universities and research institutions are interconnected through NACSIS' nation-wide packet switching network.

In response to the rapid proliferation of local area networks and specialised networks for academic research, a TCP/IP based Internet Backbone, SINET, with nine Network Operation Centres (NOCs), has been established. SINET is being connected to the current packet switching network and also to the international Internet through NSFnet.

Extensive research and development have been carried out to support these and other operations. Projects include the exploration of a large-scale transaction processing architecture, electronic library service, computerised keyword extraction, and user friendly multimedia interfaces. International collaborative studies that include East Asian language processing have also been conducted.

MESC has recently started the promotion of basic research using a budget from Grant-in-Aid for Scientific Research called New Programme. The Science Council recommends two to three research items per year to MESC and then MESC arranges the necessary budgetary and administrative procedures so that selected research can be conducted in a variety of fields, such as human genome, micro functional machine, biochemical devices and high speed communication.

NACSIS is also a central research institute for information science and communication engineering which supports MESC's budgetary and organisational arrangements, including those of the New Programme.

6.1.3 R&D project/programme

6.1.3.1 Nippon Telegraph and Telephone Corporation (NTT)

Nippon Telegraph and Telephone Corporation (NTT) provides the broadest range of telecommunications services in Japan. The company has a history of more than a century.

Founded as Nippon Telegraph and Telephone Public Corporation in 1952, NTT was privatised in 1985.

During fiscal year 1991, NTT's operating revenue was US$ 47 billion, with an ordinary profit of US$ 2.7 billion. There were 249 000 employees and 56 million telephone subscribers.

NTT has a long-standing commitment to innovative research and development. Goals of NTT's R&D are advanced services, networks and systems vital to NTT business and pioneering research to contribute to science and technology on a global basis.

NTT has twelve research laboratories and two development centres, with 3 100 people working in laboratories and a total of 8 600 people engaged in R&D activity in the whole corporation.

Four of the research laboratories - Network Information Systems Labs, Human Interface Labs, Transmission Systems Labs and Radio Communication Systems Labs - are located in Yokosuka R&D Centre, which was founded in 1972.

These four labs in Yokosuka R&D Centre are concerned with networks, services, operations and systems.

NTT has started comprehensive VI&P (Visual, Intelligent and Personal) experiments at its Yokosuka and Musashino R&D centres.

General R&D budget

NTT's research and development expenses were about US $ 2 billion during fiscal year 1991. These expenses were used for R&D activities in such fields as networks, network support, information processing, devices and materials.

R&D budget expenditures in VI&P experiments are expected to increase in coming years.

Visual, Intelligent & Personal (VI&P) research

i) N-ISDN Applications

The N-ISDN has been used on a commercial basis as the INS NET 64/1500. To further expand its applications and convenience, NTT is busy developing a variety of new application systems. These are now being tested in the VI&P experiment laboratory. The experiments include the following new trial services:

- soft copy facsimile mail service;
- ISDN image date filing system;
- intelligent tele-view;
- personal multimedia communication computer;
- ISDN public-phone-type multifunction terminal;
- multimedia presentation system.

ii) Optical subscriber transmission system

NTT is conducting a wide range of R&D that involves optical subscriber transmission systems, optical fibre cable, optical MDF and outdoor or in-house writing systems, among others. NTT has developed the following three models to meet a variety of customer needs, from business to home use:

- narrow-band digital optical subscriber system;
- frequency division multiplex optical subscriber transmission system;
- high-speed digital optical subscriber system.

iii) ATM switching systems and transmission equipment

NTT has already developed a pre-prototype switching system and an experimental ATM (Asynchronous Transfer Mode) transmission system to confirm the feasibility of each technology and is now evaluating an integrated network which can handle services with various communication speeds switching modes.

iv) B-ISDN application

NTT is performing experiments to evaluate the serviceability of prototype terminals connected to the experimental B-ISDN switching system. The experiments include the following new trial services:

- three-dimensional video display system;
- high-speed HDTV videotex system;
- personal multimedia multipoint teleconference system (PMTC system).

Schedule

NTT believes that VI&P applications will expand from business to home use. The company will, therefore, conduct its experiments in two phases:

Phase I (1991 through 1992) comprises the expansion of existing INS services, new broadband corporate network services based on ATM technology and applications, and optical subscriber transmission systems.

Phase II (beginning in 1993) will further develop B-ISDN services and applications for home use incorporating ATM switching systems, IN (Intelligent Network) and radio access systems.

Estimation

NTT has determined service target for the provision of visual, intelligent and personal services for the year 2005.

6.1.3.2 Real world computing program (MITI)

Objectives

a) Outline

It is very difficult to process incomplete and incorrect information in the real world by using conventional computers. On the other hand, it will be essential to have even more advanced information processing in the highly advanced information society of the 21st century.

A technology that can process large amounts of "incomplete information" with real time features will have to be developed. For this reason, the Real World Computing (RWC) programme aims to develop a new innovative information technology that will enable flexible processing by using functions for learning and recognising, through international co-operation.

b) Social results

The establishment of basic technology which can handle large amounts of raw data in the real world, such as sounds and images, will contribute to the rapid improvement of human communication and the further progress of scientific technology. As a result, the realisation of a highly advanced information society will be further ensured.

The following are several specific examples of applications:

1. Rapid progress in scientific analysis (solutions can be produced very quickly and precisely). In addition, even for problems where the difficulty is in discovering algorithms, solutions can be produced without programmes.

   -- global environment analysis and forecasts;
   -- weather analysis and forecast;
   -- intelligent robots.

2. Rapid improvement in communications between humans and machines (real-time processing of diversified, ambiguous and incorrect information such as image and sound, difficult to process by conventional computers).

   -- integration of sound recognition, understanding of speech and automatic translation;
   -- automatic classification of large amounts of raw data.

Budget

The total budget for RWC is estimated to be 60 billion yen (approximately US 500 million) by the year 2002.

Table 3. **Projections for 2005**

Telephone subscribers	70 million
ISDN subscribers	20 million
Pocket telephone	20 million units
Text mail terminals	20 million units
Visual telephones	5 million units
Major advanced services	3-D video communications
	Translation communications
	Personal services
New tariff structure	Minimise distance distinction
	Multiple option charging
Proportion of high speed, broadband network	30%

6.1.3.3 Structure

a) International joint research (Europe, Asia)

The Real World Computing Partnership will be established as a core organisation for research and development. Several overseas organisations are scheduled to participate in the execution of international joint research.

b) The RWC network

The RWC network will be formed as a base facility to enable research exchange between researchers all over the world. The functions are as follows:

-- remote utilisation of massively parallel systems, etc. in the central laboratory;
-- remote access to research information of the central laboratory;
-- information exchange between dispersed personnel in R&D.

c) Japan-US co-operation

Under the Japan-US Science and Technology Co-operation Agreement, the research and development of optoelectronics (which is a key technology in RWC) will be accelerated. In an action plan scheduled for January 1993, both countries agreed to co-operate in implementing a feasibility study for setting up research infrastructure (a matching environment of design technology and device technology in optoelectronics).

d) Joint system with domestic universities

A close research co-operation system with domestic universities will be formed with research consigned by the Real World Computing Partnership.

e) Joint system with ETL

A close joint research system will be formed between the Real-World Computing Partnership and ETL. ETL will mainly be in charge of leading fundamental research.

f) Outlook of demand for advanced telecommunications and computation systems

A brief survey was made of the demand for advance telecommunications and computation systems in Japan. **Table 4** shows the comparative hardware installation rate of industry for each year. The figures in the table were calculated under the assumption that the installation ratio in 1985 was 100. This ratio will increase remarkably in the tertiary industries. It will grow 4.1 times from 1985 to 1995, gradually increasing the gap between tertiary industries and secondary industries.

Table 5 shows the comparative software expenditure ratio classified by industry. The tertiary industries are higher than all industries in the growth of software expenditure, as well as in the growth of the hardware installations.

Table 6 shows the comparative telecommunication capacity ratio. The future growth rate for secondary industries is predicted to be higher than that for tertiary industries.

The predicted growth rate for secondary industries increased because a number of industries showed a large change in the growth rate.

6.1.3.4 The fifth-generation computer systems project (MITI)

Project summary

Aiming at innovative computer development suitable for knowledge information processing, MITI has invested a total of 54 billion yen since 1982 to conduct research and development into the fifth generation computer.

The major achievements of fifth generation computer project include the development of:

1. Parallel inference machines;
2. Parallel inference software;
3. Knowledge-based management software;
4. Knowledge programming software.

The points stressed by the committee include:

a) Social and policy perspective

- -- The project has performed basic research on knowledge-processing parallel inference machines. International co-operation was explicitly stated as a goal of the project at the outset.

- -- The developed technologies have been released and disseminated extensively. ICOT, the nucleus of the project, is regarded as the focal point for international exchange of research information in this field. International collaboration with foreign research institutes has been promoted.

- -- This project aims at international collaboration. For this reason, the project has conducted basic research during the implementation phase and made all achievements available.

Table 4. **Comparable hardware installation ratio by industry (annual comparison; base year is 1985)**

Industry	1985	1986	1987	1988	1989	1991	1995
All industries	100.0	112.6	127.8	145.0	163.5	208.3	339.7
All industries (excluding finance and information services)	100.0	111.9	123.0	136.4	153.2	188.0	286.3
Secondary industries	100.0	108.2	116.6	122.8	136.8	157.1	212.4
Chemical	100.0	122.7	129.7	163.3	161.7	219.3	361.4
Food and cigarette manufacturing	100.0	119.5	116.2	131.7	148.4	174.0	248.1
Transportation machinery manufacturing	100.0	94.9	115.3	116.2	138.8	157.8	222.5
Construction	100.0	89.3	93.7	104.6	117.0	121.1	146.4
Electronic machinery manufacturing	100.0	104.4	111.5	120.4	131.0	148.4	194.8
Tertiary industries	100.0	114.5	131.3	153.2	175.5	233.0	410.3
Rental	100.0	112.1	123.9	149.4	154.5	200.3	318.2
Wholesale	100.0	109.2	117.4	127.1	141.7	166.0	233.1
Transportation and Telecommunication	100.0	107.1	110.5	133.1	135.3.	161.6	224.6
Finance	100.0	109.4	123.2	140.3	156.5	196.3	310.1
Information processing service	100.0	110.7	134.6	149.4	176.3	233.3	414.0

Source: MITI's State of Information Processing Survey.

Table 5. **Comparable software expenditure ratio classified by industry (annual comparison; base year is 1985)**

Industry	1985	1986	1987	1988	1989	1991	1995
All industries	100.0	110.7	124.6	141.2	161.3	203.1	328.2
All industries (excluding finance and information services)	100.0	110.6	123.4	138.7	156.5	194.7	304.8
Secondary industries	100.0	109.9	119.4	131.5	143.6	172.5	248.2
Chemical	100.0	112.0	123.7	138.5	151.9	188.4	286.4
Food and cigarette manufacturing	100.0	109.5	110.7	122.2	134.3	151.8	201.0
Transportation machinery manufacturing	100.0	111.2	120.1	137.2	155.7	191.1	296.2
Construction	100.0	106.0	110.3	117.1	123.1	136.5	167.5
Electronic machinery manufacturing	100.0	109.0	120.6	133.5	147.1	178.5	263.5
Tertiary industries	100.0	111.6	127.1	144.8	167.6	214.8	360.4
Rental	100.0	106.3	109.8	117.9	128.2	142.4	181.0
Wholesale	100.0	104.4	108.5	115.5	121.8	133.8	163.0
Transportation and Telecommunication	100.0	115.6	135.3	157.1	178.2	241.2	432.9
Finance	100.0	112.8	128.8	149.5	172.5	225.5	390.5
Information processing service	100.0	105.0	112.0	118.0	130.2	145.7	188.6

Source: MITI's State of Information Processing Survey.

Table 6. **Comparable telecommunication capacity ratio classified by industry (annual comparison; base year is 1985)**

Industry	1985	1986	1987	1988	1989	1991	1995
All industries	100.0	114.4	132.9	191.2	211.4	321.5	718.0
All industries (excluding finance and information services)	100.0	116.4	131.2	203.8	228.4	868.0	304.8
Secondary industries	100.0	120.0	124.5	199.1	238.4	361.3	889.0
Chemical	100.0	121.1	123.4	213.8	210.1	332.6	756.0
Food and cigarette manufacturing	100.0	129.1	110.6	187.4	452.4	639.0	2 481.0
Transportation machinery manufacturing	100.0	95.0	112.5	147.5	165.6	216.3	385.0
Construction	100.0	129.3	137.3	237.3	253.3	429.3	1 154.0
Electronic machinery manufacturing	100.0	119.7	125.6	225.0	260.6	427.9	1 185.0
Tertiary industries	100.0	112.2	130.1	179.3	197.9	289.4	602.0
Rental	100.0	118.7	127.3	213.4	210.7	336.4	772.0
Wholesale	100.0	105.9	118.8	171.8	172.9	244.7	460.0
Transportation and Telecommunication	100.0	135.1	156.9	254.2	200.2	261.1	809.0
Finance	100.0	99.1	115.5	160.7	164.6	225.6	407.0
Information processing service	100.0	120.7	136.1	150.4	182.8	239.2	423.0

Source: MITI's State of Information Processing Survey.

b) Future directions and developments

It is important to disseminate the technology developed in the project to the international science community. It is essential to establish an environment where researchers, who have not been part of the project, can access and use the technology developed by the project. So far, the software products produced by the project can be used only on the hardware systems developed by the project. It would be appropriate to make these software products available for the Universal Operating System (UNIX), which is widely used overseas for research and development. This would implement the fusion of the fifth-generation computer technology with existing computer systems, and would therefore assist in the establishment of a research infrastructure in this field.

It is appropriate for the government to launch a project to establish this infrastructure in no more than two years.

6.1.3.5 New Programme on developing an academic research network

Objectives

In 1974, MESC formulated a research programme called the N-1 Project, which aimed at developing the first Japanese computer network with joint efforts of the University of Tokyo, Kyoto University and Nippon Telegraph and Telephone Public Corporation. At an earlier phase of the project, packet switching, which was the final phase of CCITT's standardisation, was selected for the communication scheme for the computer network.[36] The project had developed N-1 protocol architecture and software in order to demonstrate the feasibility of use of packet switching for the computer network.

Results from the N-1 project are being widely utilised for the current Japanese computer network called the N-1 network.

The New Programme is to start during fiscal year 1993. Five years of research and development will produce the future academic research network of Japan. The National Centre for Science Information Systems (NACSIS) is to be the central institute in implementing the programme. Core researchers include NACSIS, the University of Tokyo, Saitama University and Nippon Telegraph and Telephone Corporation (NTT).

The New Programme is to select asynchronous transfer mode (ATM) for the basic communications scheme which enables cell-based high speed communications in the gigabit/sec range. An experimental ATM system, which is now being manufactured, will provide high speed transmission and exchange, while an optoelectronic local area network, a newly devised scheme to meet with the ATM interface, will introduce it to institutes with a feasibility demonstration.

Utilising such facilities, the New Programme devises new communications architecture based on ATM. Interfaces of high performance computers or information processing equipment, control procedures for communication admission and communication quality management, high performance protocols with several layers and other relevant features to utilise ATM efficiently, are included in the list of research objectives. Development of a control element and a protocol processing element is also included.

To enhance academic applications, image processing and image retrieval are essential items. By joining institutes specialising in image processing, the feasibility demonstration will include typical applications of access to classical literature and access to images gained by space explorers. The distributed application of high speed communication network is also to be demonstrated.

The New Programme develops future network technology, network architecture and applications for academic research. The results are to form the basis of a Second Generation Science Information Network which will be developed by NACSIS.

Budget

The New Programme will start in April 1993 and end in March 1998. The total budget from MESC amounts to 600 million yen over the five-year period.

Structure

The New Programme will include communications and networking researchers from universities and industry. Most active and prominent researchers from universities and industry in this field will participate in this Programme.

International symposia to exchange results from identical activities are also scheduled. The first symposium will be held in the autumn of 1995.

6.2 High performance computing and communications in the United States

The attached report presents the findings of the site visits of the HPCC Research team at Bellcore, Morristown, N.J., Bell Laboratories, Murray Hill, N.J., and the Theory Center at Cornell University, Ithaca, New York.

The report has been prepared by Messrs. Kenneth Flamm (Brookings Institution) and Fred Weingarten (CRA), both members of the US Research Team.

6.2.1 Introduction: background and purpose of the OECD project

On 18-22 October 1992, the OECD team visited several research sites in the US associated with high performance computing and communications.

Several national governments are undertaking experiments in high speed data communications. These experiments, if successful and done in ways that will support eventual interconnection, are likely to serve as the prototypes for, or forerunners of, a global high speed data infrastructure.

The Organisation for Economic Co-operation and Development (OECD), in co-operation with the National Science Foundation, the European Community, and Japan’s Ministry of International Trade and Industry, is undertaking the preliminary phase of a multinational research programme surveying and analysing these experiments. The effort will be of use to the Member nations in several ways:

-- Each experiment is based on a set of technological, social and economic assumptions and objectives. Better understanding of these assumptions and the economic and social intentions of other national programmes help national governments plan their own programmes, and help us understand how they will relate in a global network.

-- For national governments that are not now involved in these experiments, a clearer picture of how the global high speed communications infrastructure is evolving will help them anticipate and plan for their own future roles as well as articulate their own concerns and needs in international fora, including the OECD.

-- These national experiments can be important laboratories for learning more about the economic, social, and policy dimensions of high speed data communication. The OECD can play a key role in identifying and compiling valuable data and analyses gained from these experiments.

This effort is particularly timely. Recent rapid advances in information technology (IT) (e.g. primarily computers, fibre optics, and satellites), and in the ways IT is being used mean that the world is now at a critical point in restructuring its communications systems. National policy makers and industry need objective information and analysis of international trends to help their own planning. The issues are complex, however, and the technology is changing rapidly. A longer term project will be needed for this work to be of full use to the Member nations.

This project is a preliminary effort, with three objectives:

1. to collect basic information on a selected group of national experiments;

2. to determine the degree to which usable and comparable data, studies, and analyses might be available;

3. to tighten and refine a broad, preliminary list of research questions. The visitation schedule included Japan (18-24 July 1992), the USA. (18-22 October 1992) and Germany (26-30 October 1992).

The team visited two key industrial communications research laboratories, one focusing on local distribution technologies and services, the other on long distance carriage and switching. These visits were followed by a briefing on the Federal High Performance Computing and Communications programme. Finally, the team visited a major research university, one of four NSF-funded National Supercomputer Centres that is in the forefront of high performance computing and networking applications. The U.S. had felt that such an agenda would provide the broadest overview of national programmes.

6.2.2 Bellcore visits

Overview of Bellcore

Bellcore is the research arm of the seven regional Bell holding companies, formed during the divestiture of AT&T in the early 1980s. Then, Bell Laboratories was broken into two components, AT&T Bell Laboratories and Bellcore. The companies operated by the regionals are responsible for providing exchange telecommunications and exchange access services. Bellcore is that portion of the original Bell Laboratories that supported that function.

Bellcore’s annual budget for 1992 was approximately US $ 1.2 billion, of which the seven regional companies provided 89 per cent.

New technologies

An important line of research that was emphasised to the group was efforts to transmit higher rates of digital data down existing lines, thus presenting the possibility of increasing bandwidth to the home without rewiring with optical fibre or coaxial cable. Two new systems, HDSL and ADSL, were described.

Asymmetrical digital subscriber line (ADSL) is a technology for transmitting 1.5 megabits per second on one twisted pair of copper lines over local distribution line distances, around three miles. The high speed distribution is one-way. Return data rates are much lower; hence the term asymmetrical.

A high bit rate digital subscriber line (HDSL), will transmit the same bit rates in both directions using two pairs of twisted copper lines over a distance of up to about one and one half miles. These bit rates are adequate for such applications as television, video conferencing, or voice multiplexing.

Applications

A portion of the presentation was devoted to new applications, addressing the question of what applications exist for increased bandwidth. In particular, the group saw new video juke box technology, and video panning in which the viewer can move the video frame displayed within a larger possible transmitted frame.

There was also extended discussion of the use of high speed networks to distribute services. Bellcore is part of the Aurora gigabit testbed experiment, partially funded by the government under the High Performance Computing and Communications (HPCC) programme.

General discussion

The general discussion revolved around the question of which transmission speeds are necessary to deliver which user services, and, consequently, what level of service should public policy stress. The feeling was that the technology, as well as the anticipated applications, had moved beyond ISDN, although several participants had worked on those original standards. There was a general view that the home of the future would have communications paths, characterised by very high bandwidth, and a variety of new services. Telephony, now still the dominant two-way telecommunications mode into the home and office, will be steadily supplanted by wireless, cable, and private data networks.

However, technological planning, as well as developing a research agenda for the regional phone companies, was complicated by long uncertainty over the nature of restrictions on business stemming from the Modified Final Judgement that resulted in divestiture of AT&T and that continues to be debated.

6.2.3 AT&T Bell Labs (Computer Science Research Division)

Introduction and description of AT&T Bell Labs

AT&T Bell Laboratories is the part of the original Bell Labs that remained with AT&T after divestiture, and the research agenda generally serves the business agenda of AT&T. It is concerned with line distribution and switching, the manufacture and sale of equipment, and the possible provision of information services of various kinds. This visit focused on only one aspect of the laboratory work, that of the computer science division.

Xunet

Xunet is an experimental high speed testbed network developed by Bell Labs both to experiment with the technology and to provide advanced educational experiences in high speed data transmission to electrical engineering students in universities around the country. Its main purpose is to explore the construction of high speed data networks, the development of software tools for network management, and the development of applications for such networks.

The network is currently being upgraded to gigabit speeds using ATM technology, and research with it has been folded into the Blanca gigabit testbed experiment under the HPCC programme. (Bell Labs contributes to the programme and is a co-operating partner, but has received no funding from NSF.)

Yswitch

Yswitch is an experimental switch designed to packet switch at multi-gigabit speeds in a dense fabric. Most very high speed switch designs work only for a relatively thin density of network. If the network of the future is to be truly universal, wholly different design concepts will have to be developed. This switch, developed to support a very high speed in-house switched local area network (LAN), uses novel memory structures to get around some of the limitations of a shared memory switch.

Quality of service measurements

In past networks, each level of service basically came with precisely defined minimum guarantees of quality for all users. The Internet has no specific definable and variable metrics of quality. In the intelligent, highly flexible public network of the future, it should be possible for the user to specify and purchase service according to various metrics of service quality at any time (bandwidth, reliability, maximum transmission times, and so on). Researchers using the Xunet system were experimenting with designing metrics, pricing schemes, and metering techniques for delivering such variable quality.

At Bell Labs the OECD team met with the following attendees from AT&T:

Dr. Ravi Sethi, Director Computer Science Research
Dr. Prathima Agrawal
Dr. Charles R. Kalmanek
Dr. Hemant Kanakia
Dr. Srinivasan Keshav
Dr. Samuel P. Morgan

6.2.4 Conclusions

In gigabit experiments, there seems to be a tradeoff in research between ubiquity (density of the network fabric) and raw transmission speed. There was some discussion on whether the balance that was being struck in the gigabit experiments would be fully applicable to the needs of a public switched network which would work at somewhat slower speeds, but have far more connection points. Service metrics, particularly in the area of service quality, and pricing were also identified as topics of importance for a public network.

Once again, however, as at Bellcore, researchers were moving as rapidly as possible toward a day not far in the future (by telephone company standards) when megabit, if not gigabit service, would be delivered universally. It was for this reason that Bell Labs put up its own support to participate in the gigabit testbed experiments.

Finally, the emphasis of the Xunet programme on education was noted. The managers of Bell Labs had decided that a major impediment to developing very high speed communications technology was the lack of well-trained researchers coming out of graduate engineering programmes. Furthermore, this human resource shortage was principally due to lack of access to experimental technology. Hence, Xunet was designed as an educational as well as a research testbed, a project involving engineering schools at several participating universities.

6.2.5 HPCC briefing

Messrs. Weingarten and Flamm conducted a briefing for the project team on the current state of the High Performance Computing and Communications (HPCC) programme, including current prospects for funding and the debate over the nature and future of the NREN. Details of the HPCC components and the agencies involved are set out in **Tables 7 and 8**.

For the second year, the administration's budget requested a 23 per cent increase in high performance computing and communications. Once again the programme, identified as an Interagency Presidential Initiative, was accompanied by its own special supplementary booklet, Grand Challenges 1993, high performance computing and communications. Copies of these booklets were provided to the visiting team.

In 1991, Congress appropriated $654.8 million for the 1992 HPCC programme, actually US$ 16.5 million over the administration's original Fiscal Year (FY) 1991 request, which mainly reflects an increased level of effort on the part of some of the smaller participants, such as the National Oceanic and Atmospheric Administration (NOAA) and the National Institute for Health (NIH). This year's request was for US$ 802.5 million. **Table 9** shows how the requested funds will be distributed among the agencies. NSF's US$ 61 million increase in FY 1993 was the largest, not only in dollars, but by percentage increase (30 per cent for NSF compared with 18 per cent for DARPA, 18 per cent for Energy, and 25 per cent for NASA), and also shows how funds have been allocated for these four components among the participating eight agencies.

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Tables 9 and 10 distinguish reprogrammed and new funding for HPCC appropriated by Congress for the period 1991 to 1995.

Table 7. **Four basic components**
High performance computing and communications programme of the United States (1991-1993)

High Performance Computing Systems (HPCS)

Future Generations
System Design Tools
Advanced Prototypes
Evaluation of Early Systems

Advanced Software Technology and Algorithms (ASTA)

Software for Grand Challenges
Software Components and Tools
Computational Techniques
High Performance Computing Research Center

National Research and Education Network (NREN)

Interagency Interim NREN
Gigabits Research and Development

Basic Research and Human Resources (BRHR)

Basic Research
Research Participation and Training
Infrastructure
Education, Training and Curriculum

Table 8. **Eight agencies**

DARPA

--Development of advanced computer system technology
--Gigabit technology R&D

NSF

--Basic research and human resources
--NREN deployment
--Infrastructure and software tools for Grand Challenges

DOE

--System evaluation
--Applications software development

NASA

--Development of, and access to, HPC application software base

NIH

--Medical and library applications

NOAA

--Physical modelling and data base applications, such as climatology

EPA

--Applications in the area of environmental modelling

NIST

--Standards for gigabit transmission
--Network security
--Performance measurement

DARPA	Defense Advanced Research Projects Agency
NSF	National Science Foundation
DOE	Department of Energy
NASA	National Aeronautics and Space Administration
NIH	National Institute of Health
DOC/NOAA	Department of Commerce: National Oceanic and Atmospheric Administration
DOC/NIST	National Institute of Standards and Technology
EPA	Environment Protection Agency

Table 9. **High performance computing and communications 1993 cross agency funding (in $US millions)**

				FY 1993 by Programme			
Agency	FY 1991	FY 1992	FY 1993 request	**HPCS**	**ASTA**	**NREN**	**BRHR**
DARPA	183.0	232.2	275.0	119.5	49.7	43.6	62.2
NSF	169.0	200.9	261.9	28.6	125.6	45.1	62.6
DoE	65.0	92.3	109.1	10.9	69.2	14.0	15.0
NASA	54.0	71.2	89.1	14.1	61.4	9.8	3.8
NIH	13.5	41.3	44.9	4.2	22.6	7.2	10.9
DoC/NOAA	1.4	9.8	10.8	0.0	10.4	0.4	0.0
EPA	1.4	5.0	8.0	0.0	6.1	0.4	1.5
NIST	2.1	2.1	4.1	1.1	1.0	2.0	0.0
Total	**489.4**	**654.8**	**802.9**	**178.4**	**346.0**	**122.5**	**156.0**

Table 10. **Summary of national funds for HPCC in the US (new money)**

	1991	1992	1993	1994	1995
1. High Performance Computing System	55	31	141	173	216
of which:					
-- Res./future generation	11	17	24	32	37
-- System design tools	10	18	21	25	25
-- Adv. prototype development	22	36	65	86	116
2. Advanced Software Technology and Algorithm	51	90	137	172	212
of which:					
-- Support for Grand Challenges	9	19	34	43	48
-- Software composition	15	30	41	60	78
-- Computational technology	6	10	18	19	31
-- HPCC centres	21	31	44	50	55
3. National Research and Educational Network	30	50	95	105	110
of which:					
-- Inter-agency NREN	14	23	55	50	50
-- Gigabit R&D	16	27	40	55	60
-- Development of Gigabit	(Funding begins after five years)				
-- Structural adjustment to commercial services					
4. Basic Research	15	25	38	46	59
Total HPCC Programme	**151**	**256**	**411**	**502**	**597**

Ever since this briefing, the HPCC programme of the US government has been extended by the Bill on Information Infrastructures and additional funding has been provided.

The Initiative consists of four basic programme elements:

-- HPCS (High Performance Computing Systems): to accelerate the development of future generation high performance computer systems;

-- ASTA (Advanced Software Technology and Algorithms): to develop computational tools, and resources for using high performance computers, particularly in Grand Challenge research areas;

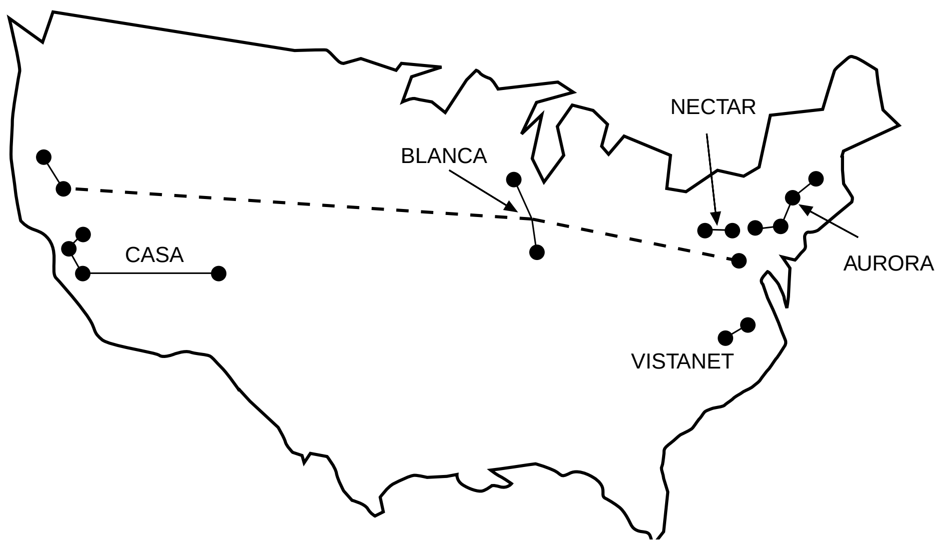
-- NREN (National Research and Education Network): to develop and support high speed data communications networks to serve research and education;

-- BRHR (Basic Research and Human Resources): to support the underlying needs for basic research and education required for the programme.

6.2.6 Five GIGABIT testbeds

One of the objectives of the government HPCC initiative is the establishment of a gigabit National Research and Communication Network (NREN) to interconnect some 250 universities and major national and private research laboratories in the U.S. To determine the actual requirements of these institutions and hence to assist in the capacity planning and deployment of such gigabit networks, the CNRI[37] has been charged with installing five testbeds in the U.S. **Figure 7** presents their geographical deployment.

Figure 7. **Gigabit testbeds in the United States**



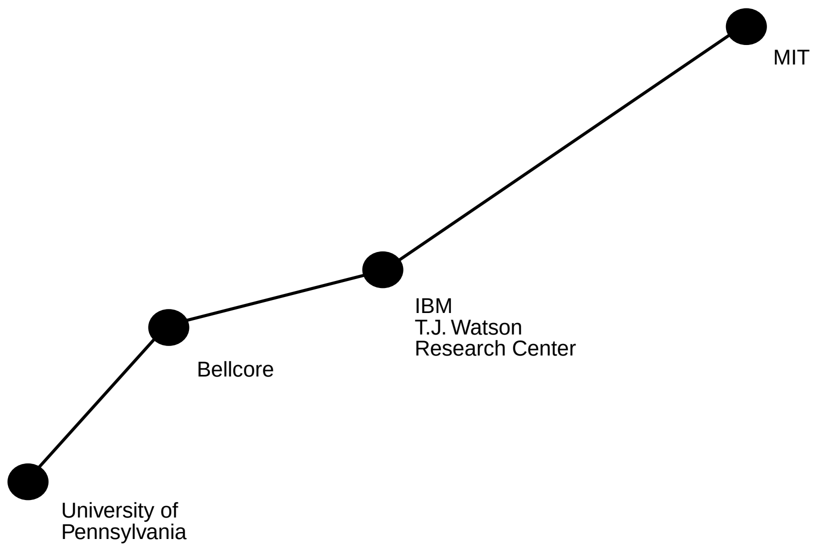
As the research team did not visit these sites, only a brief description of the objectives and the scope of these testbeds is presented below for information.

a) *AURORA*

Participants

The project involves researchers from Bellcore (NJ), IBM (NY), MIT (MA) and the University of Pennsylvania (PA), in collaboration with Bell Atlantic, MCI and NYNEX. The testbed is to link four sites: Bellcore's Morristown Research and Engineering Laboratory in New Jersey; IBM's Computer Science Research Laboratory in Hawthorne, New York; MIT's Laboratory for Computer Science in Cambridge, MA; and University of Pennsylvania's Distributed Systems Laboratory in Philadelphia, PA. (**See Figure 8**).

Figure 8. **The AURORA testbed**



Scope and area of investigations

The scope of AURORA is the exploration and evaluation of alternative networking technologies appropriate for gigabit networks.

Two distinct wide area approaches are followed, ATM and PTM (Packet Transfer Mode, in contrast to the small ATM cells), to offer alternative solutions for major research topics. Subsequent to the deployment of the independent ATM and PTM networks, they will be interconnected in order to understand inter-operability of the technologies.

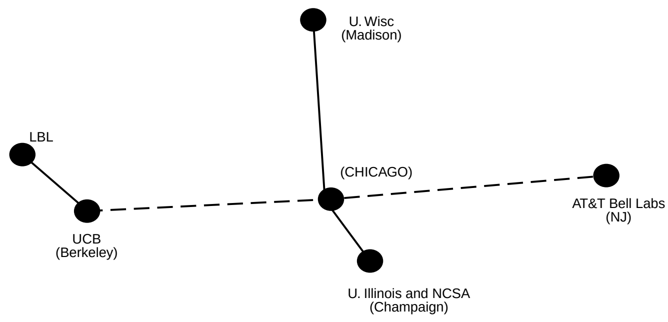
b) *BLANCA*

Participants

The project involves the Lawrence Berkeley Laboratory (LBL), the National Center for Supercomputing Applications (NCSA), the University of California at Berkeley, the University of Illinois at Urbana-Champaign and the University of Wisconsin at Madison (see **Figure 9**). Industrial collaborators are Ameritech, Astronautics, Bell Atlantic, Pacific Bell and AT&T.

BLANCA builds on the ongoing Experimental University Network (XUNet) program that fostered research and collaboration among the three universities, being jointly sponsored and directed by AT&T, Americtech, Bell Atlantic, and Pacific Telesis.

Figure 9. **The BLANCA testbed**



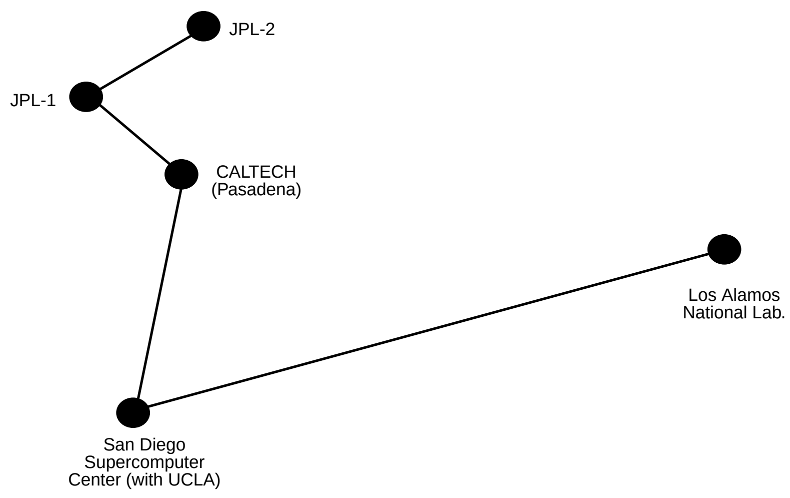
From the first testbed-XUNet I, that provided wide-area communications at 1.5 Mb/s, the network evolved to XUNet II using 622 Mb/s switches and linking additionally AT&T Bell Labs, NCSA, and LBL. Cray Research will connect to the University of Wisconsin's XUNet switch via a 565 Mb/s circuit provided by Norlight Corporation.

c) CASA

Participants

The CASA testbed involves the Los Alamos National Laboratory (LANL), New Mexico; the California Institute of Technology (CALTECH) and the Jet Propulsion Laboratory (JPL), Pasadena, California; and the San Diego Supercomputer Center (SDSC) in conjunction with the University of California at Los Angeles (UCLA) (see **Figure 10**). Other collaborators from the communications carriers community are MCI, Pacific Bell and US West.

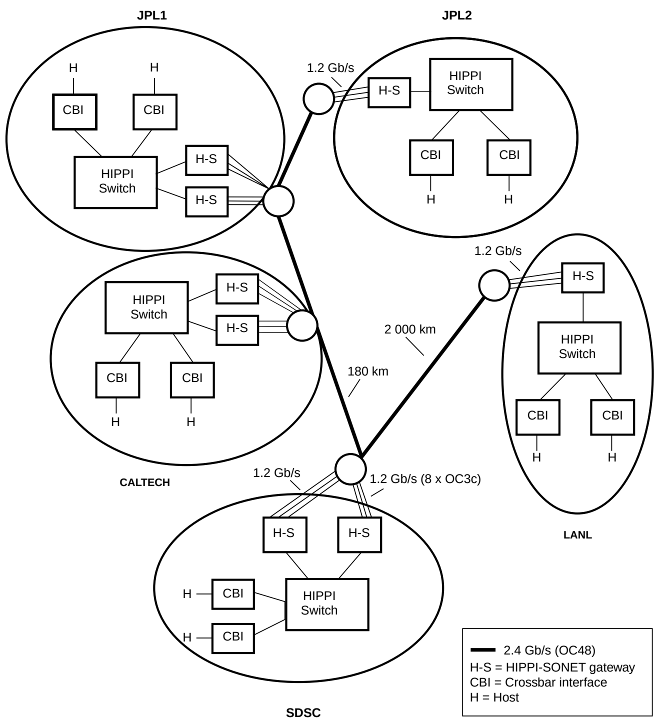
Figure 10. **The CASA testbed**



Scope and area of investigations

The focus of this testbed is on multi-computer distributed applications using wide-area high speed networks with relatively high communications latency. This distributed supercomputing environment should provide new levels of computational resources for leading-edge scientific problems (see **Figure 11**).

Figure11. **CASA network facilities**

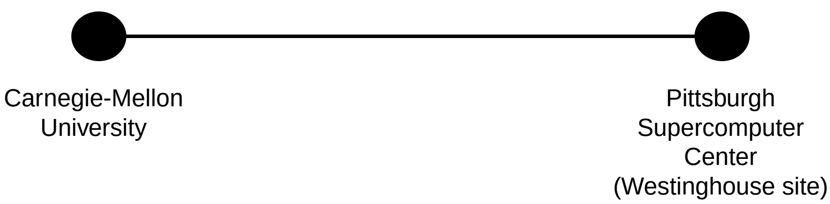


d) NECTAR

Participants

The NECTAR testbed project involves the Carnegie Mellon University (CMU) and the Pittsburgh Supercomputing Center (PSC), with the collaboration of Bellcore and Bell Atlantic/Bell of Pennsylvania (see **Figure 12**).

Figure 12. **The NECTAR testbed**



The testbed connects the two sites at CMU and PSC, approximately 30 km apart. CMU's NECTAR project was one of the ongoing projects on which the gigabit NECTAR testbed is based. NECTAR was conceived as a system for interconnecting heterogeneous computing resources via optical fibre links, large crossbar switches (called HUBs) and dedicated network co-processors (called CABs).

Scope and area of investigations

The project focuses on local area gigabit switching, operating systems, network communications software, programming environments, and distributed applications. The gigabit NECTAR aims to extend the capabilities of the former prototype (with links running at 100 Mb/s), and produce a next generation of NECTAR with 1 Gb/s or faster links. One area of investigation is the development of a SONET interface supporting ATM, to enable the connection of the testbed to future telecommunication networks.

The initial programming environment for a heterogeneous system (the result of collaboration between the Mach OS project and the NECTAR project) will be extended to include the CRAY, the iWarp and many workstations. The full protocol suite needed by the applications will be developed.

e) VISTANET

Participants

The project involves BellSouth, GTE, the University of North Carolina (UNC) at Chapel Hill, and MCNC in conjunction with North Carolina State University (see **Figure 13**). All sites are in North Carolina and the network spans only a relatively small geographical area of approximately 28 km.

Scope and area of investigations

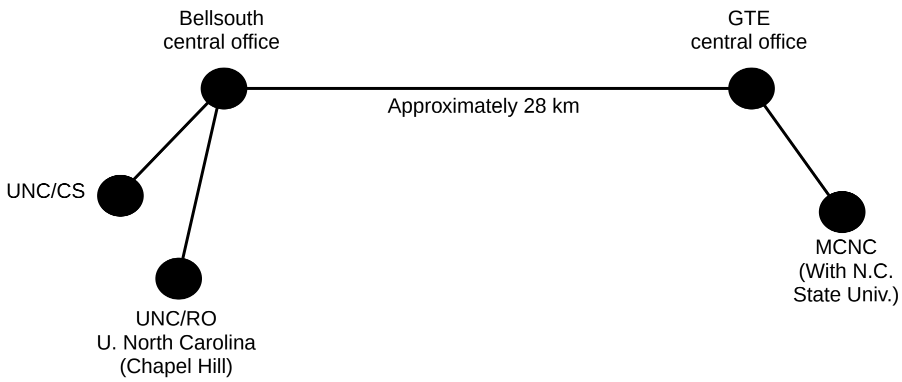
VISTANET research is focusing on medical applications. The project will provide a vehicle for the investigation of key broadband networking technologies, and will demonstrate the value of a gigabit network in metacomputing.

From the network technology perspective, research topics include protocols, performance analysis, and switching technologies (ATM and broadband crossconnect) including their internetworking, to support multiple service-class gigabit networks.[38]

6.2.7 Cornell University

Actual research within the HPCC programme will take place at testbed sites. With a view to maximising the chances of agreement on acceptable network alternatives, these testbed sites have been designed to permit close co-operation between universities, national laboratories, supercomputer centres, and major industrial organisations, including user industry, telecommunications operators and computer manufacturers. The OECD team visited Cornell University, one of the premier research universities in the United States. Cornell has a particularly strong computer science programme, a system of progressive, computerised research libraries, and it houses one of four National Supercomputer Centers established by the National Science Foundation nearly ten years ago (the other three National Super Computer Centers are at the Universities of Pittsburgh, Illinois and San Diego). The object of the discussions was to gain a user and application perspective on high speed networking.

Figure 13. **The VISTANET testbed**



a) Background on Cornell's use of information technology

Discussion started with Dr. M. Stuart Lynn, Vice President for Information Technologies. Cornell has a long history of innovation in the use of scholarly technology. It views new computational and communication tools particularly the Internet and its successors leading to an eventual National Research and Education Network (NREN), as more than just improved research tools, but as forming a basic new information infrastructure that is fundamentally transforming how research is done in all fields. Hence, Lynn's job as a senior administrator at the University, is to assure that these new technologies were adopted quickly and in the most effective way possible.

b) Electronic library projects at the Mann Library

The Mann Library is principally an agricultural research library. Cornell is New York State's land grant college and has a major state agricultural research facility. It has several projects under way which use electronic technology to make information resources more accessible, not only to campus researchers, but to scholars all over the world.

Three projects were described. The first was the Mann Library Gateway, a user interface from the Internet to a variety of data bases both on campus and off campus. The second project is an effort to put full text and image abstracts of American Chemical Society Journals in electronic form, eventually accessible through the network. The final project was building a portable electronic agricultural library on optical disk. Such a library could be cheaply and easily distributed around the world, particularly to third world agricultural research stations.

6.2.8 Tour of theory centre and visualisation lab

The Cornell Theory Centre is the only National Supercomputer Center based on IBM hardware. It runs two vector/scalar IBM ES/3090-600 supercomputers, each of which has six processors. The facility is due to be upgraded to a single six-way IBM ES/9000-900 supercomputer, with potentially 2.66 gigaflops peak speed.

The Cornell Center combines the efforts and support of academic researchers, government agencies, the computer industry, and user industries, who are just learning how to put supercomputers to use.

Using a new IBM system, called PVS (for Power Visualisation System), the centre supports both education in graphics and research in visualisation techniques. Modern research is focused on how to convey efficiently to a human eye the extraordinary amount of information generated by a supercomputer, and convey it in such a way as to make important details noticeable and understandable.

Later in the morning, attendees returned to Lynn's office for a more detailed demonstration of the Gopher/WAIS network database system.

6.2.9 Conclusions

Cornell provided several examples of research and experimentation on the uses to which high speed networks will be put. High speed national infrastructure programmes could be viewed by many as technology push programmes if questions are not asked about their potential application. But, Cornell HPCC efforts have strong application development components. Furthermore, the Internet was the platform for unexpected developments, such as the WAIS and Gopher information retrieval technologies, and for the Cornell experiments in slow scan video. The need will be to put experimental platforms in the hands of creative users.

6.3 Canadian Network for the Advancement of Research, Industry and Education

6.3.1 Introduction

CANARIE stands for Canadian Network for the Advancement of Research, Industry and Education. Designed for facilitating the exchange of ideas and the development of new products and services, it will significantly influence Canada's communications infrastructure for the 21st century. Through the provision of better test facilities, more balanced use of national resources and upgrading skills and knowledge, CANARIE will also ensure that Canada remains at the forefront of international developments in telecommunications.

CANARIE is a national initiative and a national opportunity. Its mission is to stimulate the creation of an electronic communications capability for all Canadians by the year 2000. It will achieve its mission by first organising, through its members, an improving array of communications services for the education community, and the public and private sector research communities. A surge of new technologies, software and applications emanating from laboratories and test facilities will flow into operation networks for the research and education communities. These technologies and applications will later be diffused into our public networks. The research and education communities will benefit from advanced facilities and the information industry suppliers will develop new products and services to increase their international trade.

Other nations are making significant investments to exploit the synergies between computers and telecommunications. They are building faster and more capable communications networks to support their R&D and education communities and are thereby building a more competitive capability in the world's information technology markets. These countries recognise that support for high speed networking in R&D and education can be a catalyst to improved competitiveness in the information technology sector. The whole economy benefits as a result.

CANARIE will join the intellectual resources of Canada to stimulate increased productivity, creativity and wealth generation. It will go beyond basic resource sharing and become culture transforming. CANARIE will truly enable world-class high speed communications, information networking, research and development, information access, and the creation of new education techniques. Benefits from CANARIE will be realised in virtually every sector of the economy. In particular, it is expected to support the development of a new communications infrastructure, crucial for the emerging knowledge-based economy, and thereby contribute to competitiveness in all sectors of the economy; to prosperity, job creation, and to quality of life.

Furthermore, CANARIE aims at providing an environment in which the Canadian information technology industry can accelerate the development of future generations of open networking technologies, products, applications, software and services; and at supporting more effective research, development and education through enhanced collaboration and access to information and resources world-wide.

6.3.2 Implementation and investment plan

The CANARIE initiative will be implemented in three phases (see **Table 11**). Total direct and indirect investment for Phase I will be CAN$ 115 million, of which the federal government will contribute CAN$ 26 million and the private sector will contribute CAN$ 89 million.

6.3.3 Development

For the past four years, more than 200 people from 56 organisations, representing Canada's research, university, business and government communities, have developed the concept and business plan for CANARIE to respond to the challenges that Canada faces.

Table 11. **The three phases of the CANARIE initiative**

Phases	**Time frames and activities**	**Direct and indirect investment**
Phase 1	(April 1993 - March 1995)	
	Upgrade and market the national R&D and educational network	CAN$ 115 million
	Establish a high speed experimental test network	
	Initiate product and service development	
Phase 2	(April 1995 - March 1998)	
	Operate the high speed experimental test network	
	Stimulate the development of new networking technologies, products, applications, software and services	
	Continally upgrade the R&D and educational network	
Phase 3	(April 1998 - March 2000)	
	Migrate application and technologies to operational networks	

6.3.4 Applications and potential participants

The application and potential participants of the CANARIE initiative are set out in **Table 12**.

Table 12. **Applications and potential participants of the CANARIE initiative**

SECTOR	POTENTIAL APPLICATIONS	POTENTIAL PARTICIPANTS
Health Care	Collaborative diagnosis High-resolution image transfer Distance education Radiation treatment planning Medical supply sector	Rural/urban hospitals Physicians Medical researchers Teaching hospitals
Pharmaceutical/Biotechnology	Molecular dynamic analysis Access and tools to analyse data from the Human Genome project	University researchers Government researchers Pharm/biotech companies
Aerospace	Concurrent engineering • Universities • IT suppliers • Airline operators/carriers	Manufacturers
Astronomy	Distribution of data from Hubble Telescope and elsewhere	Researchers Media
Agriculture	Access to remote imaging data for crop forecasting Canadian Wheat Board Farm Supply Board	Researchers Grain trades
Fisheries	Access to remote imaging to: • Government agencies • Fish processors	Researchers
Forestry	Access to remote imaging data to: • assist forest management • improve conservation methods • monitor pests/disease • plan harvesting • provide early detection of fires	Forest industry Government agencies Forestry ministries Environment ministries Emergency response agencies Environmental groups University/research community
Natural resources • Mining • Gas development	Interactive 3-dimensional reservoir/formation analysis systems	University research and education Oil exploration and production Mining exploration and Seismic survey firms
Education/skills training	Distance education Computer-based courseware	Provincial education ministries Public and private school boards Corporate training centres
Media/communications	Collaborative programme development Remote access to video librairies	Producers/broadcasters Cable operators Satellite distributors
Finance/banking	High speed document transfer Advanced banking systems	Bank and trust companies Others
Urban planning	Access to remote imaging data Collaborative analysis with Geographic Information	Urban planners Environmental protection agencies

6.4 HPCC sites visited in Germany and at CERN in Geneva (October 1992)

This part of the report contains the main findings of the OECD inquiry on High Performance Computing and Networking (HPCC) in Germany and CERN in Switzerland.

The report covers the visits and presentations at:

1. TUBCOM (Technical University of Berlin, Broadband Communications Technology Research Centre)
2. DFN -- Deutsches Forchungsnetz (German Research Network);
3. BERKOM (Berlin Communications System)
4. Siemens Presentation on ATM
5. RUS -- University of Stuttgart (Regional Computing Centre, Institute for Computer Applications)
6. ICA -- Institute for Computer, Applications, University of Stuttgart
7. PAGEIN (Pilot Applications on a Gigabit European Integrated Network)
8. CERN (Centre for High Energy Physics Research, Geneva)

This section of the report also contains national HPCC Programmes of selected European countries which were presented at EIIT meetings or during the site visits:

-- HPCC programme of the Ministry for Research and Technology (BMFT, B. Reuse, Bonn);
-- HPCC in Finland (Prof. R. Nieminen);
-- HPCC in the United Kingdom (Dr. Cooper, Rutherford Lab.).

6.4.1 TUBCOM (Technical University of Berlin)

Hosts: Dipl.-Ing M. Wolff, G. Kalkbrenner, J. Schlosser

Established in 1978, TUBCOM is a research centre located at the Technical University of Berlin with a mission to advance applications in multifunctional broadband communications technology. The centre operates in partnership with German industry and other research institutes (German Heart Institute, Physics Institute, etc.), and collaborates in a variety of CEC Programmes within ESPRIT and RACE.

TUBCOM's objectives are to:

-- provide a testbed for broadband communication technology;

-- develop innovative broadband communication applications;

-- integrate multi-vendor (heterogeneous) systems based on OSI;

-- develop linkages with other networks, such as the Berlin B-ISDN network BERKOM and the European pilot broadband network EBIT (**E**uropean **B**roadband **I**nterconnect **T**rial);

-- apply broadband communications to academic teaching and research.

In collaboration with ANTC (Advanced Networking Test Centre) of Sunnyvale, California and EANTC (European Advanced Networking Test Centre), TUBCOM installed a high speed broadband fibre optic network in 1990 at a cost of DM 15 million. The network links the departments of the university with workstations, servers and bridges based on a 100 Mbps FDDI (Fibre Optic Distributed Interface) token ring technology. The basic topology of the network is shown in **Figure 14**. In turn, TUBCOM is to use the B-ISDN facility at BERKOM (**Figure 15**) to access external and international networks.

Figure 14. **Integration des TUBKOM-Netzwerkes in das B-ISDN**

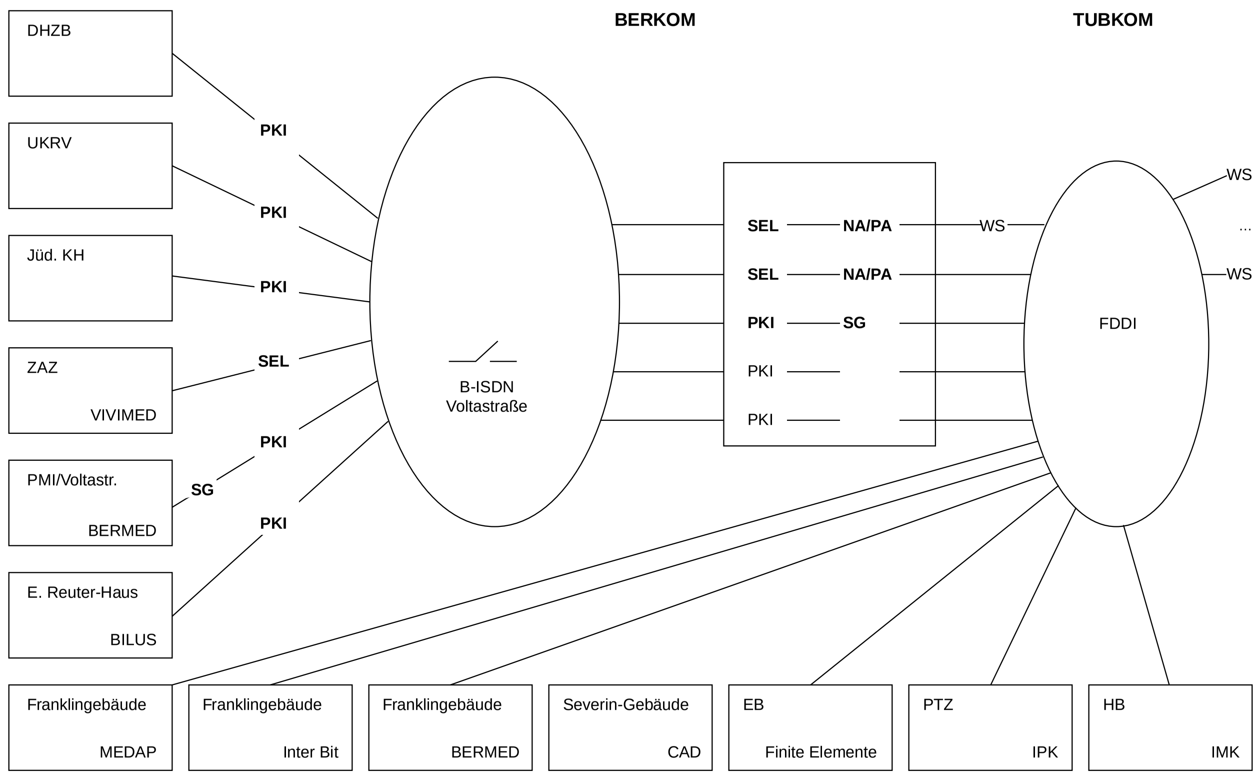
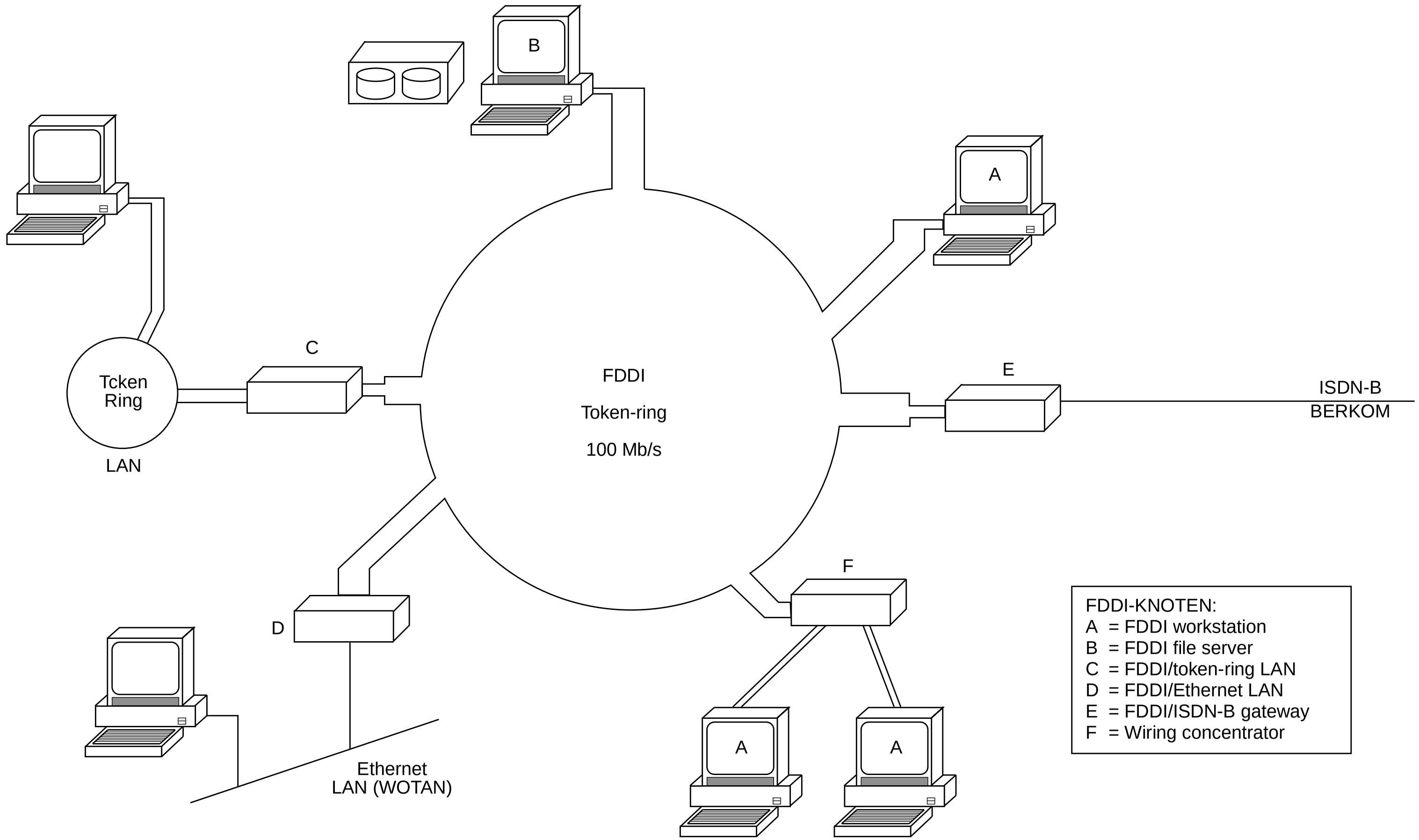


Figure 15. **TUBKOM high-speed-network**



TUBCOM's work on application development encompasses the following areas:

- -- integrated computer aided engineering;
- -- distributed CIM (Computer Integrated Manufacturing);
- -- CAD and graphics;
- -- distributed knowledge based systems;
- -- HDTV;
- -- computer aided medical diagnostics and therapy;
- -- messaging with high resolution video communications;
- -- computer integrated chemistry;
- -- tele-teaching via high speed networks.

While primarily a university teaching and research system, TUBCOM's test facility is also exploited by industry. Producers of FDDI network equipment have access to the TUBCOM network for products and components testing. In fact, collaboration with industry and research centres is becoming a major source of income for TUBCOM (believed to be about DM 500 000 annually).

6.4.2 DFN (German Research Network)

Host: Dr. Peter Kaufmann, Project Leader

DFN (the German Research Network) is a national research network connecting every university, college and research laboratory in Germany. Some private sector firms also subscribe. The network interlinks approximately 300 hosts in Germany, and is used for a variety of services, including messaging, distributed applications and high speed data communications. DFN is funded by the German Ministry of Research and Technology (BMFT), membership fees and service charges to users. DFN operates as a private network and leases lines of the national X.25 DBP (Deutsche Bundespost) network. A gateway provides transparency to public X.25 facilities.

It is interesting to note that users pay fixed charges for DFN service according to line speed connections (not based on traffic volume).

The current DFN usage is as follows:

-- 9.6 Kbps-Access	15 000 DM/Year	155 users*
-- 64 Kbps-Access	52 000 DM/Year	145 users*
-- 2 Mbps-Access	31 000 DM/year	12 users*

(* Each user may have several DFN connections).

DFN provides international interconnectivity to:

- -- public X.25 networks;
- -- COSINE (Co-operation for Open Systems Interconnection in Europe -- a Eureka project for OSI products);
- -- IXI/EMPB (a new European backbone network of 2 Mbps);
- -- EBONE (a 700 Kbps service via CERN, Switzerland -- being upgraded to 2 Mbps);
- -- ESNet (a USA backbone network serving the Energy Science community; currently a 256 Kbps link being upgraded to 2 Mbps);
- -- low speed service to Poland, CSFR, Romania, Russia, the Baltic, etc.

Service/application connections include:

- -- X.400 for mail;
- -- EARN (X.25 backbone integrated computational centres with IBM mainframes);

-- DoD-IP with all INTERNETs;
-- FTAM (File Transfer, Access and Manipulation application protocol; an ISO compatible file transfer standard).

The DFN administration in Berlin has plans to enhance the DFN infrastructure and application services **(Figure 16**). An upgrade to 34 and 155 Mbps services is to be introduced, although the timing is unclear. DFN is also testing some advanced network technologies such as:

-- frame relay (similar to X.25 but with the ability to send packets of bursty data without tying up the network during silent periods);

In the application areas, DFN is improving its network to widen the user base and to link supercomputer centres. It is experimenting with multimedia data bases, multimedia communications, and video conferencing (**Figures 17 & 18**).

The DFN is facing a formidable challenge in the next several years as it attempts to provide advanced networking facilities. The upgrade to high speed lines is especially expensive in Germany (an overall upgrade to 34 Mbps would cost in excess of DM 80 million/year). DFN is looking at regionalising its structure so that, as a first step, the higher speed lines would be deployed only in regions that need them (e.g., in regions with a high concentration of universities, supercomputing centres, research organisations, etc.). In turn, the regions would be connected with 2 MBps service. The regional systems are expected to cost DM 5 million/year each, and to use compatible network technologies. A move to a high speed backbone network does not appear feasible with the current rate structure.

6.4.3 BERKOM

Host: Prof. Dr.Ing. Radu Popescu-Zeletin, Section Head. Dipl.Ing. Andreas Blase

The BERKOM project (Berliner Kommunikationssystem) was started in 1986 by the Federal Minister for Post and Telecommunications to advance the development of services, applications and end systems for broadband ISDN (**Figure 16**). Berlin was picked as the site for the project because of its optical fibre and digital communication infrastructure (the project was also deemed to be of high significance in the development of a reunited Berlin). BERKOM has the backing of the Berlin Senate, which contributes some resources. Since 1992, the BERKOM project has been supported by the EC through the RACE research programme in telecommunications.

The BERKOM initiative is generally considered to be the first broadband test network of its kind in the world. BERKOM is credited for major innovations in high performance applications, especially in telemedicine and telepublishing, and for some pioneering experiments with ATM switching technology.

The operating contractor for BERKOM is DETECOM GmbH, which is a consulting subsidiary of the Deutsche Bundespost. Long term strategy is formulated by a steering committee (mainly public officials) as well as an advisory council of scientific and industry representatives, the latter responsible for establishing the work programme. Research projects performed by scientific institutions are 100 per cent funded, while industrial R&D receives 50 per cent support.

The funding provided for BERKOM by the Deutsche Bundespost and the Berlin Senate amounted to DM 190 million for the period 1986-1991. The industry participation was estimated at DM 125 million for a total investment of DM 315 millions. Some 78 government and industry partners are involved in BERKOM (14 scientific institutions, 17 private firms and 5 user groups).

At the time BERKOM was established, international standards for broadband ISDN services were simply non-existent, nor was there any clear concept of the applications for broadband communications. BERKOM met with considerable world wide interest because the project was as much concerned with user issues and market evaluation as it was with network development. BERKOM's work program consisted of 6 major thrusts:

- -- market studies to evaluate the potential of future broadband applications (3.2 per cent of the budget);
- -- application projects in medicine, publishing, distributed systems and office automation (32.2 per cent of the budget);
- -- development of a reference model for integrated services (6.91 per cent);
- -- development of end-systems, i.e. multimedia workstations (16.8 per cent);
- -- development of gateways (10.7 per cent); and
- -- development of the test network (29.4 per cent).

As indicated above, the largest single element of the BERKOM budget was allocated to application development. A brief description of each major initiative follows:

- -- Telemedicine: the retrieval of high definition radiology images (X-ray, CAT, MR, etc.) from local and remote locations;
- -- Telepublishing: the electronic distribution of publications (newspapers, magazines, etc.) and the decentralised production of high quality documents;
- -- Computer Integrated Manufacturing: the high speed data transmission in the development, production, process simulation, and process control of manufacturing operations;
- -- Information Systems: the exchange of integrated text, voice and graphics between office users.

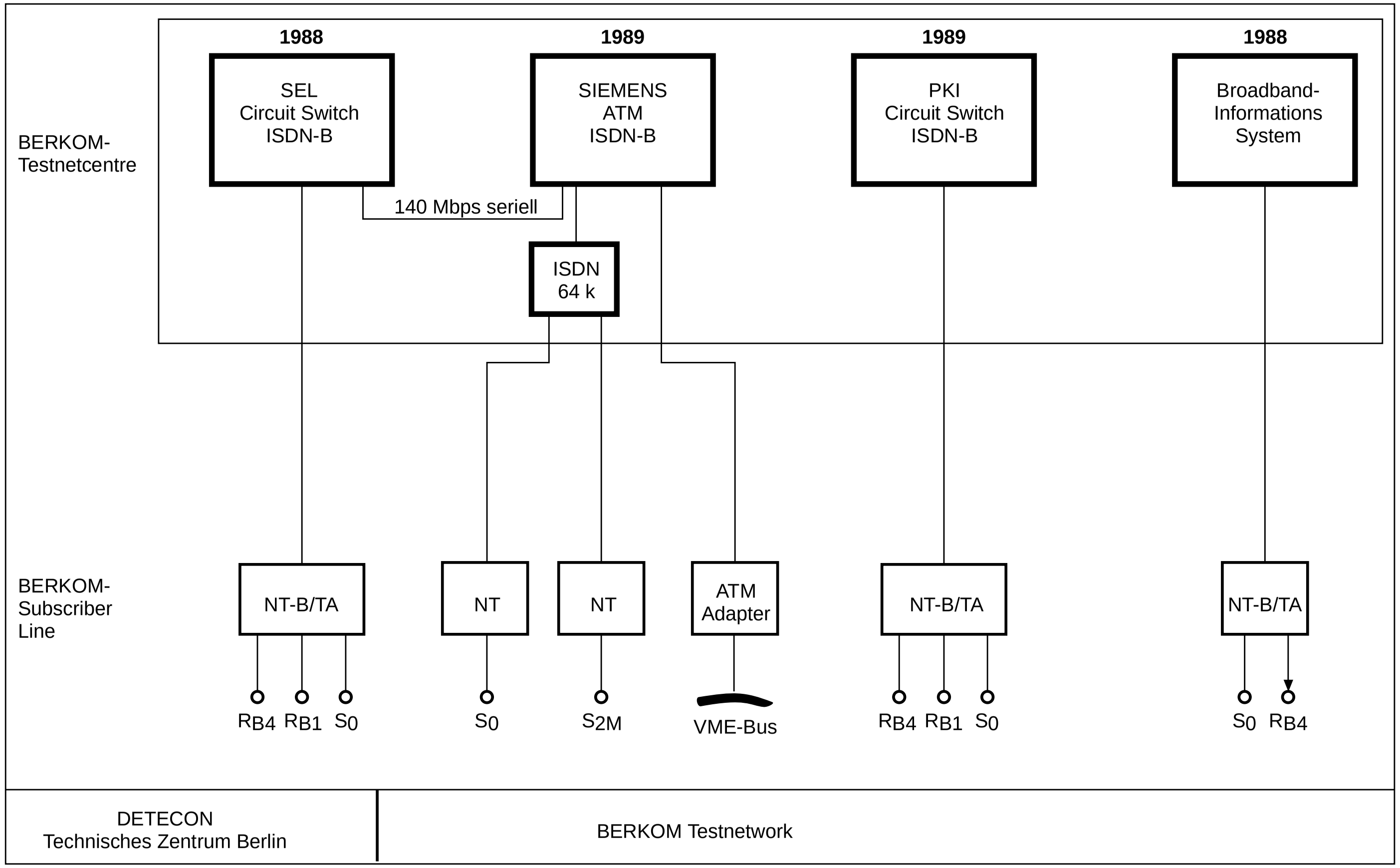
Industry is a major player in BERKOM. The test network uses two broadband switches developed by SEL Alcatel, Philips and Siemens (2 STM and 1 ATM) with 76 subscriber lines. The STM switches permit 2 Mbps and 140 Mbps connections, while the ATM switch transmits up to 120 Mbps. ATM technology appears to have gained greater acceptance as the foundation for B-ISDN. The ATM switch made by Siemens and supplied to BERKOM in 1989 was the first exchange of this type installed in the world.

Industry is also a partner in the development of end-system products to connect B-ISDN to user facilities. A variety of gateways and network adapters have been developed. Multimedia end-systems are also widely used in BERKOM.

As the first test network, the BERKOM experiment has evidently given Germany a strong lead in the deployment of broadband networks. It is not clear, however, how quickly the results of BERKOM will be transferred to a wider implementation of the technology. The high costs of broadband transmission and network investments are strong deterrents in the introduction of new services. The situation is further complicated by the uncertainties of market in which the demand for new services is immensely difficult to estimate. On the other hand, user demand will only increase if suitable networks are made available on a wider national and international scale. The most likely scenario is a step by step evolution of broadband services on a regional basis, starting in densely populated areas and dedicated campus environments.

BERKOM believes that the early use of broadband services will be characterised by the formation of virtual private networks connected to MANs (Metropolitan Area Networks). As regional demand increases, the high speed interconnection of MANs will likely take place as a second step.

Figure 16. **Enhancement of DFN infrastructure and application services**



6.4.4 Siemens presentation on ATM

Host: Dr. rer. nat. Rainer Haendel

The discussions with SIEMENS were centred on the technical aspects of ATM switching technology (Asynchronous Transfer Mode). A detailed report on the technical aspects of ATM is beyond the scope of this report, but some general observations can be made.

ATM is becoming widely accepted as a way of providing simultaneous high speed voice and data services, and SIEMENS has evidently taken an early lead in marketing ATM technology. Not everyone, however, sees ATM as the only answer for broadband network switching.

ATM is based on the requirement that networks in the future will carry different kinds of traffic (voice, data and video). While users can dedicate separate circuits for each kind of traffic, dedicated bandwidth wastes resources for any traffic that is bursty. ATM takes digital traffic and splits it up into small cells. Two or more ATM devices communicate with a constant stream of cells. If a user has traffic to send, the cells carry traffic. If not, no cell is transmitted.

An ATM switch accepts traffic from a wide variety of users. Because the cells are small, the switch is able to provide statistical multiplexing for different data sources over a single link. The ATM architecture seems ideal for wide-area environments with many different users. The use of ATM is also being considered as the basis for future LANs.

The interface of very powerful workstations to supercomputers requires very high bandwidth. The current practice is to set up a dedicated circuit for that traffic but, as noted earlier, this approach is not cost effective over long distances. There is also a need to support mixed traffic. Workstations are increasingly being used for sending video traffic to the desktop in multimedia applications, scientific visualisation or medical imaging. These multiple high speed transmissions of bursty traffic argue for a new type of public network which ATM technology makes feasible.

The Siemens briefing highlighted the main advantages to be gained in ATM networks:

-- flexibility in allocating different bit rates per connection;
-- virtual path/channel connection concepts;
-- virtually unrestricted multiplexing of different bit rates;
-- suitable for bursty traffic;
-- simplified operation and maintenance;
-- based on a widely accepted CCITT standard (but not fully defined).

Although the information was sketchy, Siemens spoke about an ATM field trial which is being set up by the Deutsche Bundespost starting in 1993 and ending in 1996. The trial involves a full B-ISDN capability and three ATM switching centres as shown in **Figures 17 and 18**. The trial will use ATM as an overlay network on top of the SDH infrastructure. SDH (Synchronous Digital Hierarchy) is a new transmission approach adopted by CENT and based on the North American SONET concept (Synchronous Optical Network). SONET was developed in order to set a standard for optical transmission and interfaces.

Siemens estimates that some significant market opportunities for ATM based networks will emerge over the next several years. The rapid growth of the LAN interworking market is an encouraging sign. Sales of LAN routers have exploded in recent years with growth rates exceeding 40 per cent annually. Major players in the computer industry are successfully promoting communication end systems (IBM started selling multiprotocol routers in 1992; others include BP, SUN, NEXT, etc.). Another favourable development is the move by end system vendors to add ATM ports to their products.

Major carriers in Japan, North America and Europe are introducing high speed data services (Frame Relay, ISDN, SMDS) which will create a boost for broadband communications.

Figure 17. **ATM pilot project in Germany**

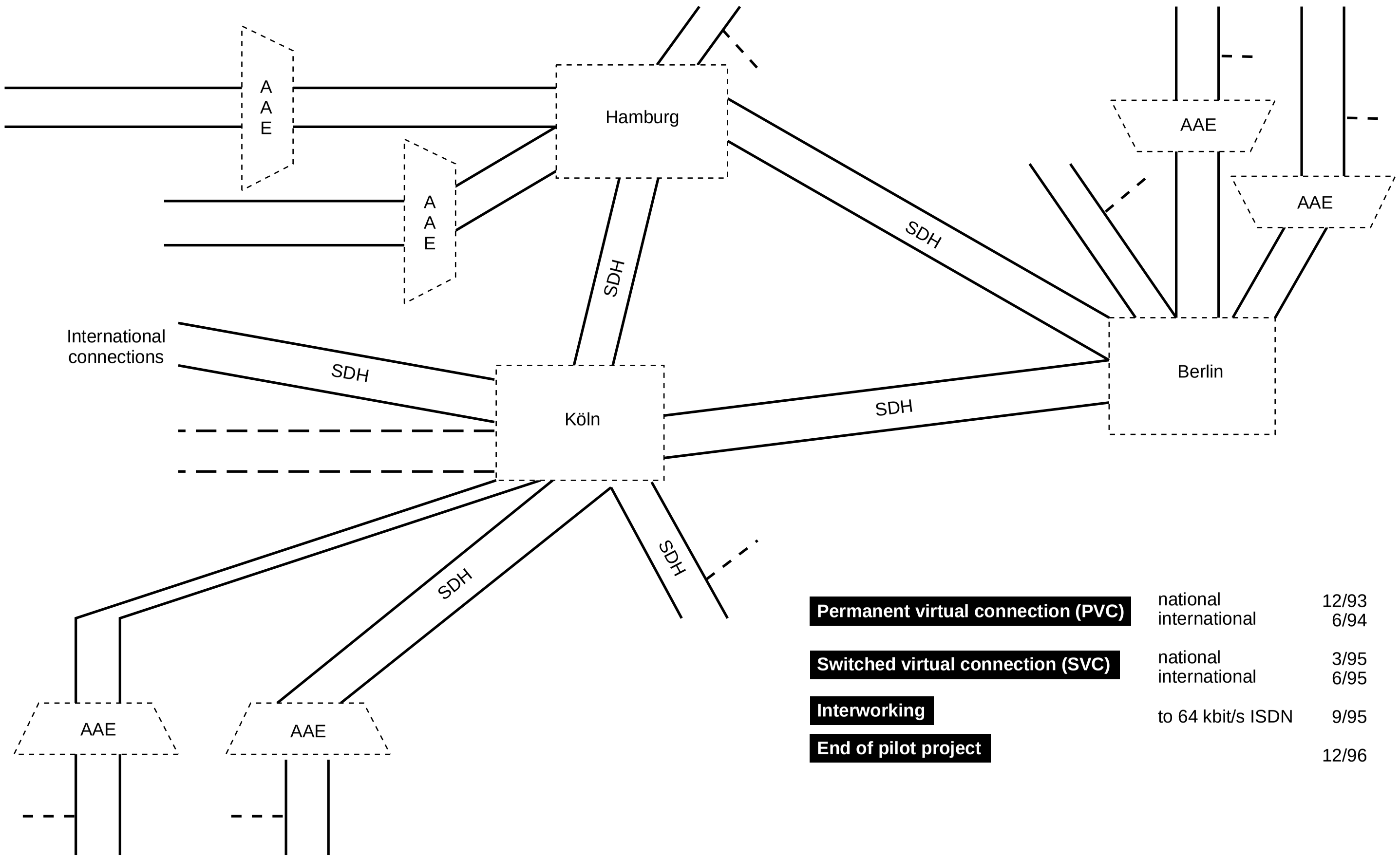


Figure 18. **Introduction of ATM**

First phase: leased line networks

- Applications:
  - LAN/MAN interconnection
  - Virtual private networks
- Technology:
  - Standards for leased line networks
  - ATM-MUX and ATM-CC

ATM overlay networks on top of SDH

- Use of SDH infrastructure
- Overlay networks for business customer

Field trials starting in 1993

Vision O.N.E.

One of the hottest emerging markets is in MANs (Metropolitan Area Network), which are optical high speed networks capable of operating at speeds of more than 100 Mbps. MANs are used for interconnecting LANs and are suitable for the high speed data communication needed by workstations and file servers. They are typically installed in a metropolitan area hence the name. They can cover a region of more than 100 km in diameter and up to 1 000 stations can be attached to one network.

Siemens estimates that a sizeable market will develop for ATM connect networks between MAN systems. The opportunity for ATM networks to connect directly to LANs was also mentioned as a strong possibility.

6.4.5 The Computing Centre of the University of Stuttgart, RUS

Host: Prof. Dr Dipl Ing R. Ruhle, Director, RUS

The Computing Centre of the University of Stuttgart (RUS) has a remarkable record as Europe's largest university-based supercomputer centre. From the early days of supercomputing in the 1960s, RUS has successively employed the most powerful computers available. The current configuration of the RUS centre is shown in **Figures 19 and 20**. RUS pioneered supercomputer network concepts in Europe, demonstrating the first gigabit transmission in 1989, and achieving a world record data transfer speed of 95 Mbps over a distance of several hundred kilometres.

In 1990, RUS was first to demonstrate high speed wide area OSI connectivity to supercomputers, transferring data between the Cray-2 system in Stuttgart and a workstation in Berlin via the German Science Network (WIN) at 64Kbps as well as via the optical fibre based broadband network (VBN) of the Deutsche Bundespost at 140 Mbps.

In 1991, RUS acquired a CRAY Y-MP 2E system as a dedicated file server to overcome a bottleneck in file access and data management. The system also acts as a buffer for 3 networks that function at different speeds: an Ethernet at 10 Mbps, a Hyperchannel at 50 Mbps, and an Ultra Network at 800 Mbps.

Over 1 000 workstations are connected to the CRAY-2 system. Among the users are German universities, research institutes and industrial research centres (Porsche, Bosch, etc.).

RUS's main function is to provide computer resources to the research institutes of the university for solving large non-linear and partial differential equations. Large scale modelling and numerical simulations in chemistry, fluid dynamics, combustion engineering, climatology, aerodynamics, material science and plasma physics are the main areas of research supported by the supercomputer centre. Scientists have access to a variety of parallel machines at RUS as shown in **Figures 19, 20 and 21**.

RUS also functions as an important testbed for infrastructure developments in collaboration with the Deutsche Bundespost and industry. Two recent experiments include:

-- The Vorlaufer Breitbandnetz VBN: essentially an automatic dialling video conferencing network using 140 Mbps fibre optic channels. RUS participated in the development of an interface between the network and FDDI (a high speed LAN network which circles the campus). The tests enabled RUS to acquire experience in high speed interfaces and applications; and

-- Metropolitan Area Networks (MAN) trials: MANs operate as high speed packet switched communications networks based on the IEEE's Distributed Queue Dual Bus (DQDB) standard. The main use of MANs is to interconnect LANs over long distances.

RUS computer inventory

RUS serves the scientific community with different classes of parallel computing:

-- Vector supercomputers:

- coarse grain
- large shared memory
- few very powerful vector processors
- machines Cray-2, Cray Y-MP, ETA-10

-- MIMD computers (Multiple instructions stream/Multiple data stream):

- medium grain
- local memory
- up to several hundred mid-range processors
- communication through message passing
- machines: Intel iPSC/2, Paragon, NCube, CM-5

-- SIMD computers (Single instruction stream/Multiple data stream):[39]

- fine grain
- massive parallelism (up to 10,000 processors)
- relatively weak processors
- small local memory
- machines: thinking machine (CM-2), MasPar.

RUS participated in the trials and demonstrated data transfer between LANs up to 155 Mbps. DQDB is closely related to ATM and is able to carry conventional data transfer as well as multimedia communications.

6.4.6 Institute for Computer Applications (ICA) at the University of Stuttgart

Host: Prof. Dr. John Argyris

In Stuttgart, the OECD team met with Prof. John Argyris, who heads the University's Institute for Computer Applications (ICA). The agenda included presentations by members of the institute on supercomputer applications in a wide range of research projects (details are available as an Annex Report through the Secretariat). All confirmed the industrial and technological importance of HPCC. In fact, these presentations clearly revealed the dynamic feedback relationships between new applications and their information processing requirements. The institute specialises in the simulation of complex physical and technical phenomena in the natural sciences. The scientific work of the institute relates to:

-- fundamental research with computer simulation into basic physical phenomena such as turbulence, combustion, non-linear dynamical systems and their transition to chaos; characteristics of new materials, such as ceramic coatings; and hypersonic aerodynamics of re-entry, including chemical transformation processes;

-- the technological utilisation of this fundamental research and its computer simulation, such as, for example, alternative energy production by means of wind power plans, industrial metal-forming and coupled thermo-mechanical processes; and

-- the utilisation of modem computer architectures, particularly parallel computers, and the development of special concepts for parallel algorithms.

6.4.7 PAGEIN

While in Germany, the OECD team heard frequent references to PAGEIN, a CEC sponsored project in gigabit communications which involves the participation of RUS and other organisations. PAGEIN (Pilot Applications on a Gigabit European Integrated Network) aims to demonstrate and evaluate a trans-European testbed for integrated broadband communication applications. The various partners in PAGEIN are shown in **Figure 22**.

PAGEIN is supported by the CEC RACE programme and is intended to advance European R&D collaboration in the integration of supercomputers, databases, knowledge servers and broadband networks with visualisation and related multimedia technologies.

The project, again, is application driven with priority given to applied research and industrial developments in the aerospace and fluid dynamics areas. A phased approach has been implemented, starting with a 140Mbs link between supercomputers and selected users, later to be upgraded to a pan-European ATM broadband network.

6.4.8 CERN

CERN is -- at least for Europe -- a paradigm. Its world-wide High Energy Physics (HEP) collaborative user community is utterly dependent on HPCC networks. CERN is more dependent on HPCC networking than even ESA, NASA, and the meteorologists of ECMWT at Reading.

The network is still a first generation network which is expected to develop further as the recommendations of the Rubbia Report are implemented.

CERN's use of HPCC networks encourages collaborative research from remote sites around the globe. Supported by the RACE programme of the Commission, its ATM Pilot project is directed towards multimedia applications and gigabit transfer rates. At this stage, its optical network, BETEL 34 Mbit/s ATM testbed, links CERN with Lyon, Sophia Antipolis and Paris.

CERN has identified telecommunications tariffs as the most important barrier to progress in pan-European networking: leased line tariffs in Europe are many times higher (5-10 times) than tariffs in the USA. This situation is claimed to be one of the factors impeding the development of a European scientific computing industry.

Data acquisition and interactive data analysis pose the biggest challenge in the HEP area. For a single LHC experiment in the year 2000, data acquisition and filtering will require the capacity of a thousand of today's supercomputers and 1 000 000 gigabits of storage. To meet these application-driven information processing requirements, on-going collaboration with computer manufacturers has been essential. For example, CERN's link to Cornell University is supported by IBM. CERN's Computer Network Development Programme involves clustering of workstations from different manufacturers.

Ultimately, to integrate LHC, HEP researchers and information resources at geographically dispersed locations will depend on a pan-European broadband network. Although fibre optic systems have increased transmission capacity, the research community deplores the fact that there is neither a European equivalent of the US gigabit network testbeds, nor competitive market structures to bring prices down.

Figure 19. **UNIX services**
Open system environment

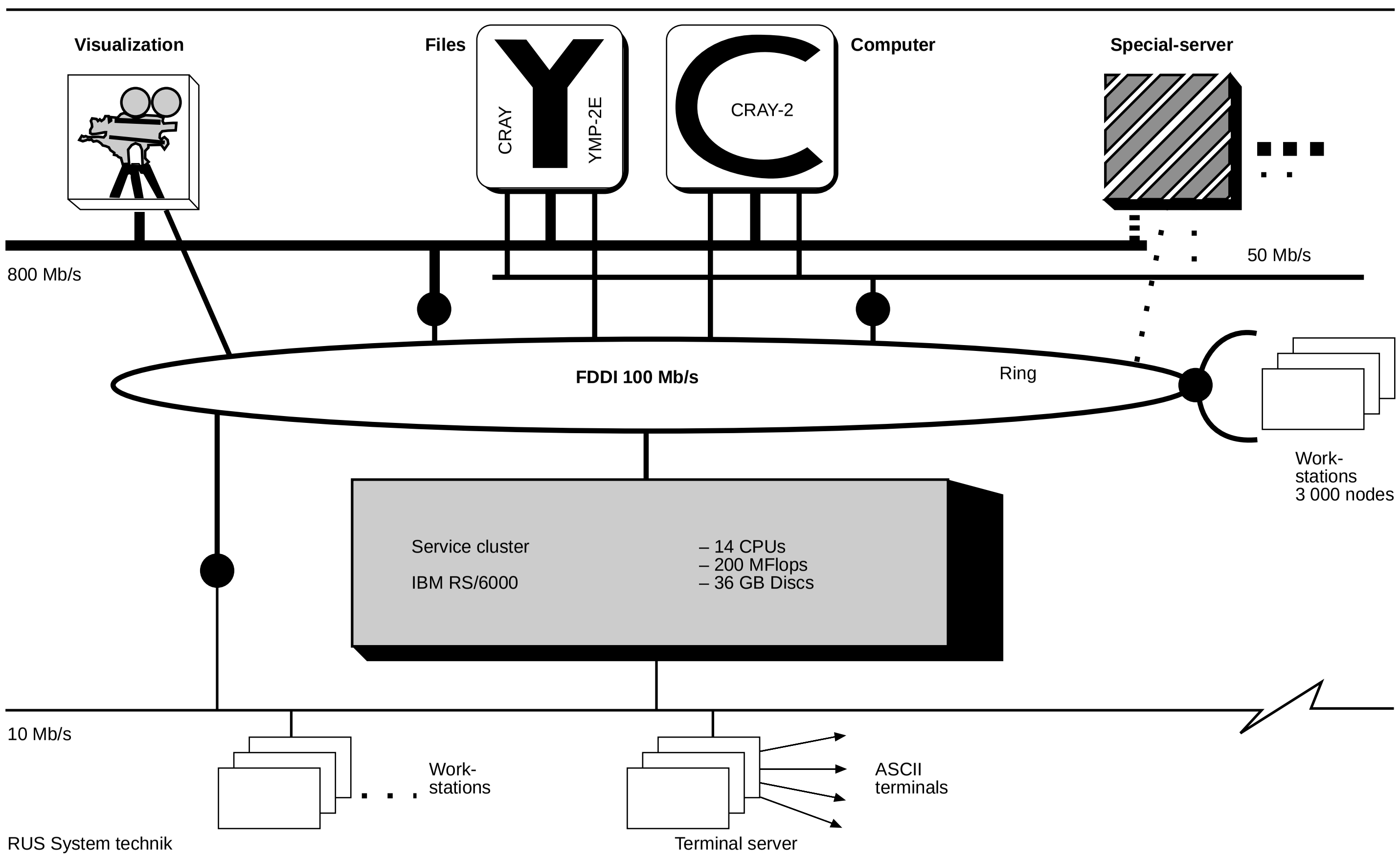


Figure 20. **Services cluster**
SERVus

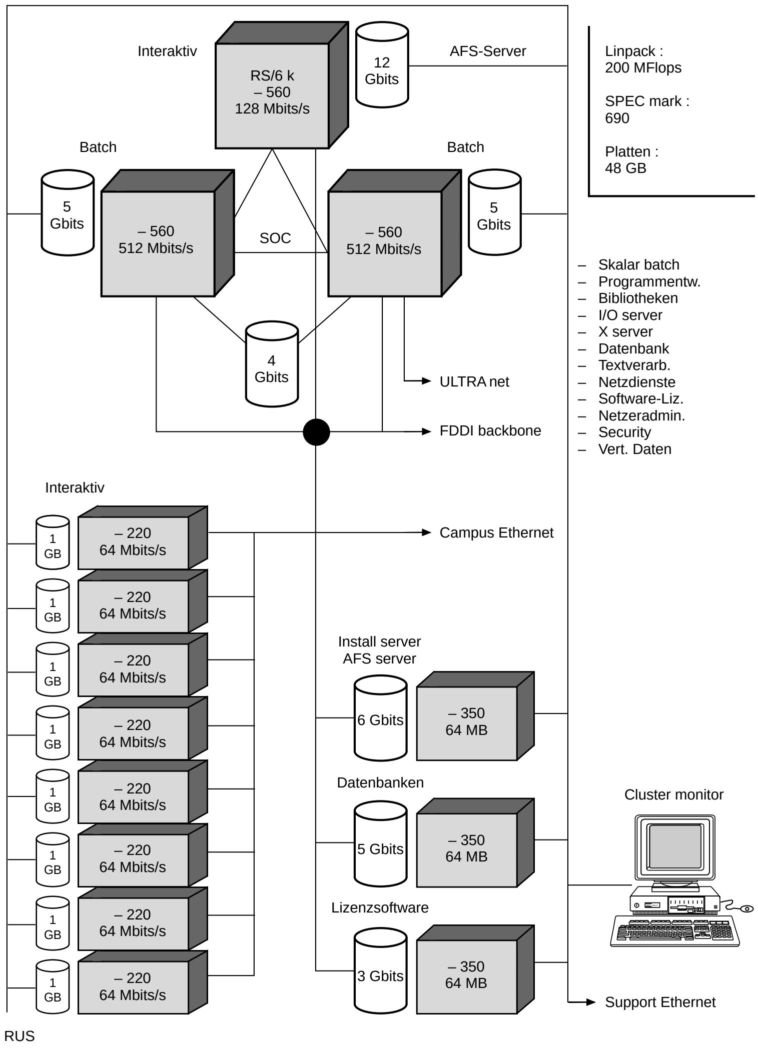
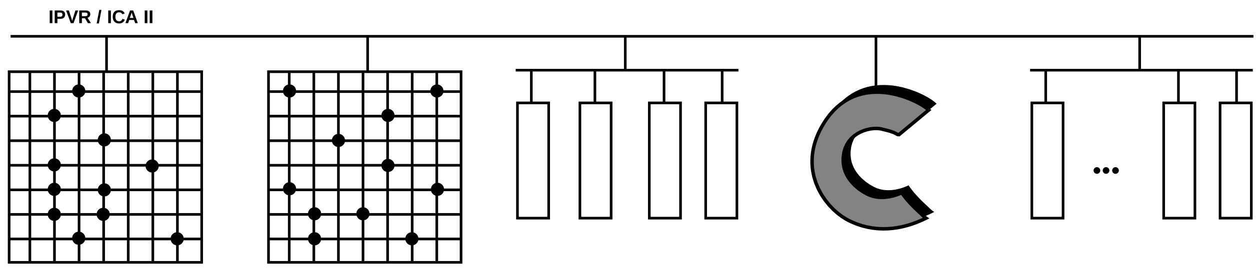


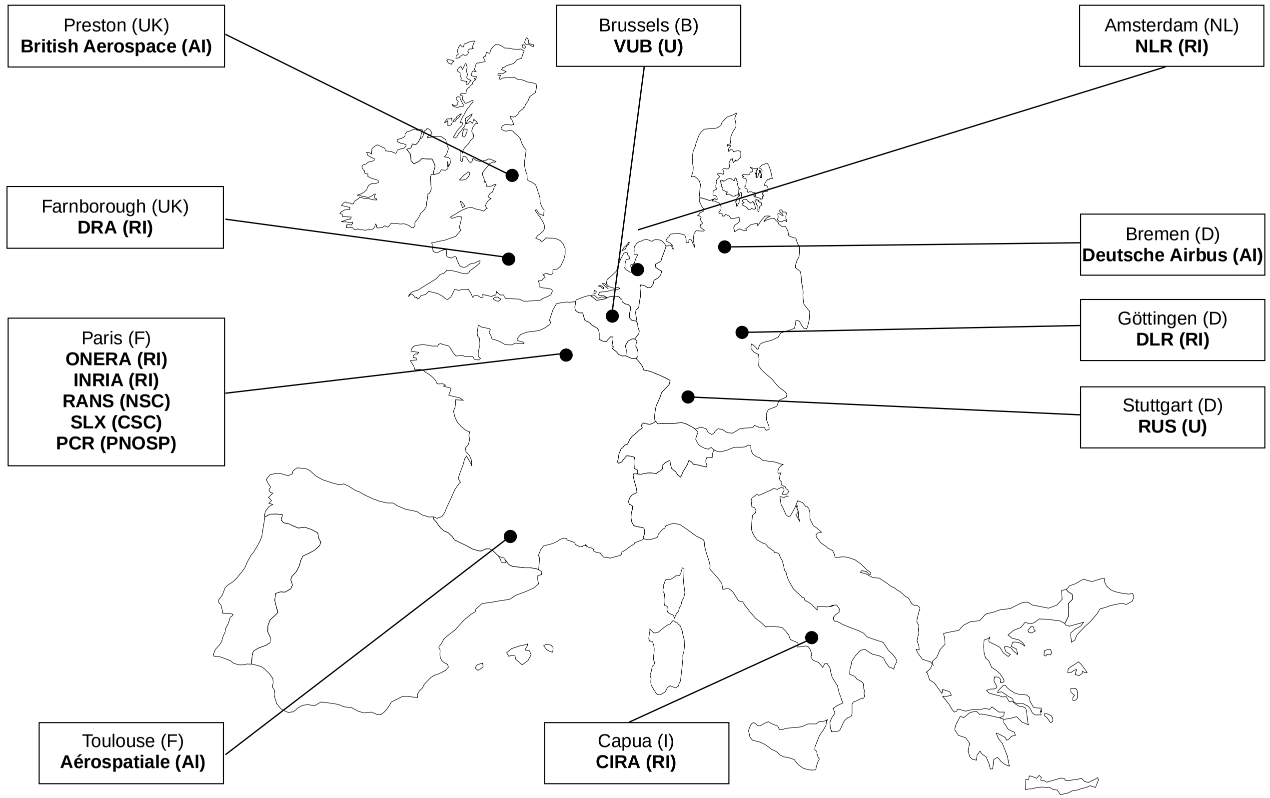
Figure 21. **RUS Computeserver**



	SIMD	MIMD	Parallel RISC	Parallel VECTOR	RISC Server
	Macpar	Intel Paragon	IBM RS 6000	CRAY-2	IBM RS 6000
Proc.	16 384	66	8	4	14
Memory	256 Mbits	1 Gbits	4 Gbits	2 Gbits	1.9 Gbits
Leistung	1.5 GFlops	5 GFlops	0.7 GFlops	2 GFlops → Nachfolger	0.9 GFlops

Source : Rechenzentrum der Universität Stuttgart (RUS).

Figure 22. **The PAGEIN Consortium**



RI = Research Institute ; U = University ; AI = Aerospace Industry ; PNOSP = Public Network Operator Services Providers ; CSC = Computer Services Company ; NSC = Network Services Company.

6.5 Public Programmes and Policies for IT and Supercomputers[40]

6.5.1 German Governmental HPCC Programme

While in Berlin, the OECD team met with Mr. B. Reuse of the German Ministry for Research and Technology (BMFT) for a discussion of the German government's policy and programmes in the information technology (IT) sector. Mr. Reuse is responsible in BMFT for information processing technologies, including supercomputers, software and artificial intelligence. In his briefing, Mr Reuse reported that in Germany, IT has been considered from the beginning as a strategic technology and that the BMFT has devised a number of support programmes with a view to develop domestic research and production capabilities in this area. **Table 13** shows the evolution of BMFT's spending for R&D and diffusion of IT.

This IT programme is intended to strengthen basic research in IT and to create a broad knowledge base and research capabilities. The BMFT programme is co-ordinated with related programmes of the Commission of the European Communities and supports the development of:

-- interdisciplinary research projects: IT and mechanical engineering, microsystem technology, IT-telecommunications, bioinformatics;

-- R&D co-operation among universities, research centres, industry and user groups, the objectives being to assist in the establishment of a powerful public research infrastructure for Germany and -- through joint projects -- to accelerate the technology transfer of research results into industrial production and use.

In 1991 and 1992 this programme was increased by another DM 300 million to support IT-R&D in the former East German territories through the establishment of appropriate research institutions. To date, the BMFT spending in information technology accounts for some 12 per cent of the total R&D budget, broken down as shown in the graph below.

This high level of R&D support and related investment (see **Table 14**) will be maintained in the medium term.

The BMFT is developing an additional HPCC promotional programme to increase R&D funding to be announced in early 1993. This programme will support HPCC related key issues in focusing on advanced HPCC applications as points of leverage. The programme is based on the assumption that massive parallel processing systems (in the teraflop range) will be developed by industry by mid 1995 without any public funding.

Table 13. **IT Research Programmes of BMFT from 1984 -- 1992**
(Millions-10^6-- of current DM)

Type	1984	1985	1986	1987	1988	1989	1990	1991	1992
Project-specific support (including support for Big Science Centres)	583	624	787	834	779	702	732	832	1 001
International support (Max Planck Society) Fraunhofer Society)	52	55	57	63	65	66	67	82	109
Total	**635**	**679**	**844**	**897**	**844**	**768**	**799**	**914**	**1 110**

Source: Informationstechnik, Förderkonzept 1993 -- 1996, Der Bundesminister für Forschung und Technologie, p. 116, November 1992, Bonn.

Table 14. **IT Programmes 1993-96**
(Millions of current DM)

Type	1993	1994	1995	1996
Institutional research	464	4590	467	477
Project specific research	671	670	670	670
Total BMFT IT promotion	1.135	1.129	1.137	1.147

Source: Informationstechnik, *op. cit.*, page 117.

BMFT support will focus on:

-- tools to adjust existing applications software to the new parallel processor requirements;

-- tools to develop new application software for parallel processing and flexible software engineering tools, including specification verification, error detection, performance monitoring, and visualisation;

-- interface standards to permit portability of application software for different systems and different parallel architectures;

-- flexible, user friendly visualisation tools for example for real time simulation of applicatio ns using HPCC; and

-- development of reliable and economically viable high speed networks in the gigabit range.

Table 15 shows the financing of this programme from 1992-1996 and describes its structure.

Table 15. **Structure of BMFT -- Funding for Parallel High Performance Computing***
(in millions of DM)

	1992	1993	1994	1995	1996
Simulation and forecasting models for all disciplines	--	2.0	4.0	4.0	4.0
Mathematical research	--	3.0	6.0	7.0	7.0
IT concepts, algorithms, methods software	9.0	8.0	12.0	12.0	12.0
Core funding for parallel processing at KFA and HP Centre at Birlinghoven	2.8	4.8	3.1	3.2	3.3
Parallel computing at GMD	15.2	14.2	15.0	15.0	15.0

* Vector Supercomputing is not included in this programme.

6.6 Supercomputing in Finland[41]

Computers enable scientists and engineers to approach challenging problems with unprecedented power and versatility. The Centre for Scientific Computing serves the Finnish R&D community in supercomputing, visualisation, networking and scientific databases.

6.6.1 Computational science

Large-scale computing and simulation are an integral part of modern research in science and engineering. Access to high speed computing tools has given birth to what is now called *computational science*. Complementing the observational, experimental and theoretical approaches, this fourth mode of science is revolutionising research across traditional disciplines. Numerical modelling allows one to attack complicated systems and problems, typically containing up to millions of variables, beset by non-linear couplings and complicated boundary and initial conditions. The term *Grand Challenges* has been coined for such problems, and they are exemplified by such far-reaching topics as global climate change, mapping of the human genome, design of new drugs, and microscopic modelling of materials properties. The computational approach also enables the scenario method: a scientist can pose new "what if"questions in addition to the usual "how" and "why".

6.6.2 Centre for Scientific Computing: the metacomputer

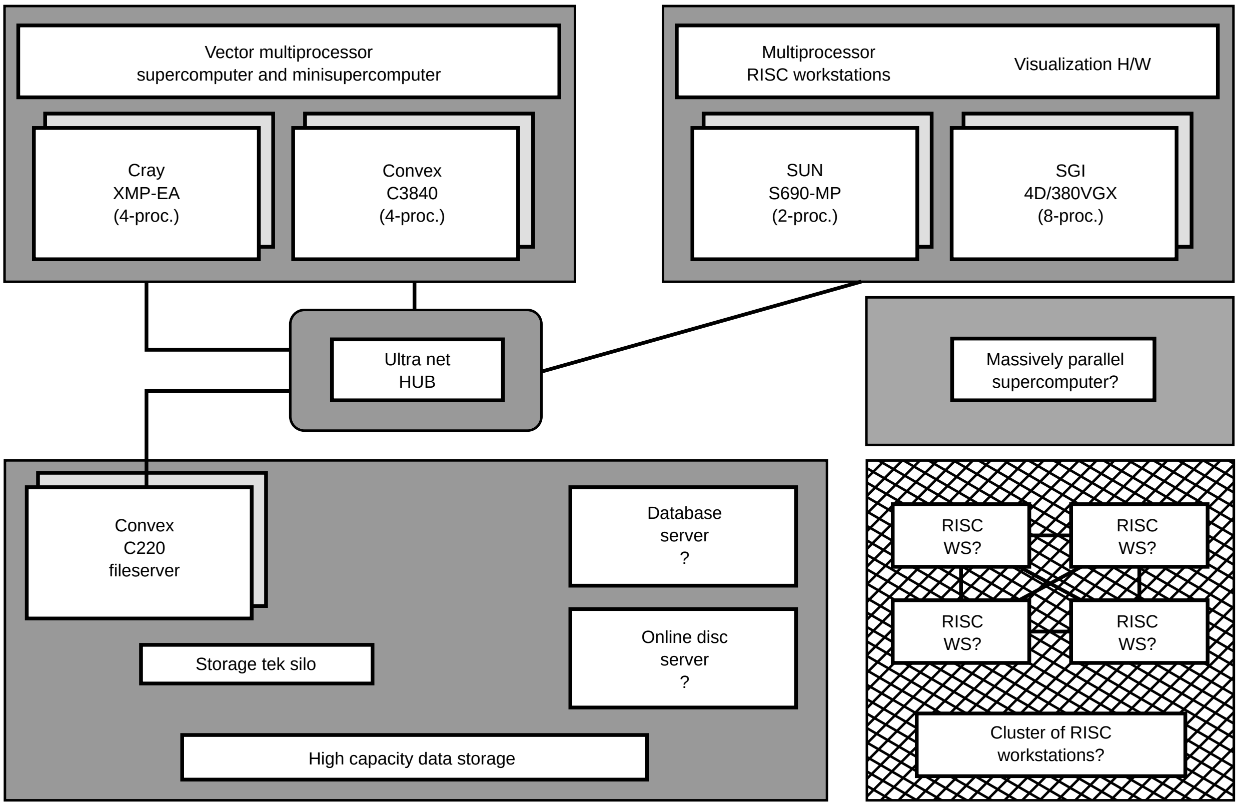
The Centre for Scientific Computing (CSC) is the Finnish National Supercomputer Centre located in Espoo, near the campus of Helsinki University of Technology. Its main function is to provide supercomputing services for academic researchers throughout the country. It also serves the Finnish Meteorological Institute (FMI), the Technical Research Centre of Finland (VTT), and industrial R&D organisations. Its facilities are accessible through the Finnish University and Research Network (FUNET), with extensive national and international high-speed communications links. FUNET is presently using the frame relay technology for networking, and is experimenting, in co-operation with Telecom Finland, advanced ATM networks. This ATM pilot network which connects five nodes in two cities 200 km apart is in fact Europe's wide area testbed. It operates at 34 Mbps, soon to be upgraded to 155 Mbps.

The modern concept for a large-scale computing facility is based on the idea of a *metacomputer*. The three major functions are fast computing, massive data storage, and scientific visualisation, connected through high speed channels. The first function is served at CSC by vector supercomputers (Cray XMP/432, Convex 3840), multiprocessor superscaler machines (SUN S690), and workstation farms. Data storage is handled by a file server computer (Convex 3220) and a tape robot (StorageTek). The core of the Visualisation Laboratory is the graphics engine (Silicon Graphics 4D/380), with optical disk and video outlets. All the machinery is coupled through a gigabit (UltraNet) network, enabling fast transfer of data as well as optimal utilisation of different computer architectures for different computational tasks (**Figure 23**).

The maximum computing speeds of "traditional" supercomputers are typically of the order of a few billion floating point operations (gigaflops) per second. They are based on the vector architecture and modest parallelism between 4-16 processors. This technology is well developed, with mature software support. The emerging paradigm in large-scale scientific computing is *massive parallelism,* with hundreds or thousands of commodity processors linked together. While this poses considerable challenges for algorithmic and software development, gains in computing capacity can be substantial. A massively parallel computer is a natural addition to the metacomputer environment.

In addition to providing the basic technical and maintenance support for the metacomputer environment, CSC provides extensive software and research support, with specialists in several areas of science and engineering. Emphasis is also placed on algorithm development in the context of research projects in computational sciences. The Visualisation Laboratory provides animation and computer graphics services for the science community. The centre also runs a program of symposia, workshops and summer

Figure 23. **Center for scientific computing: metacomputer architecture**



schools for researchers, in addition to regular user training.

6.6.3 Application areas

The CSC facilities are heavily utilised by the Finnish R&D community. Among academics, the major usage areas are the physical sciences (including astrophysics), computational chemistry and biosciences and engineering. The university usage amounts to nearly 80 per cent of the available supercomputing capacity. As the other major user, FMI runs its operative weather modelling code (HIRLAM) four times a day on the Cray supercomputer, providing accurate forecasts for up to 48 hours ahead. In addition, FMI has several computational research programmes in the areas of space science, pollution modelling and climate studies. VTT’s usage is focused on large finite-element simulations in structural engineering and fluid dynamics.

A typical supercomputing research project is the simulation of the solar atmosphere. The extreme conditions there are described in a set of non-linear differential equations of the fluid density, pressure, temperature and velocity fields, coupled to the Maxwell equations for electromagnetism. Such magneto-hydrodynamic equations show a richness of solutions only accessible via numerical techniques. The solutions reveal new and unexpected features, such as dynamo action in a turbulent situation.

Computational materials science is another exciting example. Based on computational models, scientists and engineers can predict mechanical, electrical and chemical properties of materials, ranging from biological macromolecules to magnetic media, thin films and superconductors.

6.6.4 Industrial experience

The industrial users of the Finnish HPCC facilities include companies ranging in size from large corporations to small engineering firms. Naturally, their needs also vary substantially from requirements of massive computing power to access to networks and to the utilisation of high-quality scientific visualisation.

The experience in all these three areas has been encouraging. Supercomputing is now being recognised as a viable option for verifying new design concepts, complementary or alternative to real life prototype building. Scientific visualisation techniques have made rapid inroads in such areas as marketing and training. The companies see substantial value in gaining access to the research networks.

The lack of adequate (at least 2 Mbit/s) communications links from many actual industrial sites is seen as a serious drawback. Communication costs are not considered an important issue.

6.6.5 Window to the future

Scientific computing is indispensable in attacking most of the critical R&D challenges facing us. Its infrastructure contains users' workstations, different kinds of supercomputers, graphics servers, database machines, massive archives and mail servers. Global computer networks expedite efficient communication. Open standards and unification in a multi-vendor, heterogeneous environment lead the way towards seamless computing. The computational tools open a window into the future for the scientist. To utilise fully these possibilities, it is crucial to ensure long-term development of, and research into, the computational techniques themselves.

6.7 UK's SuperJANET and its pilot applications[42]

The SuperJANET initiative started in 1989, under the auspices of the Computer Board, with the aim of creating a foundation for the development of a national broadband network to support UK higher education and research. Early discussions anticipated a network based on optical fibre technology offering very high performance with a development path leading eventually to Gigabits/sec. transmission rates. It was recognised that the development of SuperJANET would require close collaboration with a telecommunications carrier and with industry in general.

In December 1991, following support from the Secretary of State at the Department of Education and Science, the Universities Funding Council approved funding for the first phase of SuperJANET and the SuperJANET Project Team was set up to provide support for the early planning activities. The Team comprised staff from the Joint Network Team, Cambridge University, Rutherford Appleton Laboratory and University College London. The Team identified ATM as the target technology for SuperJANET and the ATM Technical Advisory Group (ATAG) was set up to support the introduction of this new technology. The Team recommended the provision of an optical fibre SDH network as the best foundation for the development of SuperJANET.

In March 1992, proposals were sought from 19 organisations for the collaborative development of a national optical fibre SDH backbone network operating at performance levels up to 622 Mbps. The five proposals received demonstrated that the SuperJANET concept was valid and that there was a high probability that the first phase of the network could be deployed within the time scale and funding guidelines envisaged.

6.7.1 Funding Council approves the project

The Tender evaluation resulted in a recommendation in favour of British Telecom (BT). The Universities Funding Council (UFC) then announced on 10 November 1992 the development of

SuperJANET, an advanced communications network for higher education in Great Britain. The contract for the new venture -- won by BT -- is worth £18 million over four years, subject to a review at the end of the installation of the pilot phase. SuperJANET will offer higher education and research institutions in Great Britain the opportunity to access the most advanced communications service to support learning and research activities.

6.7.2 Applications and network structure

SuperJANET, which uses high performance optical fibre technology, can be used to transmit voice, data and images. The applications available initially will include: high performance computing, distance learning, electronic publishing, library document distribution, medical imaging and multimedia information services. A pilot network will be established in March 1993 which will connect six sites: Cambridge, Edinburgh and Manchester Universities, Imperial College of Science, Technology and Medicine, University College, London, and the SERC Rutherford Appleton Laboratory. Additional sites will be added during 1993-94, reaching a total of around 50. Further sites may be added subject to additional funding.

SuperJANET will complement the Joint Academic Network (JANET) which has served the academic community since 1983 on 200 sites. The advantages of the new network lie in its speed and the types of applications that it can support. SuperJANET will provide much higher performance than JANET, between 10 and 100 times faster. The technology used for the network will be upgradeable to support 1 000 times the performance of JANET. This high speed allows the transmission of highly sophisticated image, voice and data communications.

SuperJANET will provide a pervasive high performance network offering wide opportunities not only for research but also for teaching applications. In some areas -- for example, medical imaging and the virtual memory library -- it will be possible to develop entirely new applications. The increased capability will improve the efficiency and effectiveness of UK higher education by allowing institutions to develop entirely new ways of storing, processing and distributing all types of information.

The SuperJANET extension to JANET delivers an infrastructure that spans a large number of academic and research sites and offers a broad spectrum performance to suit all needs, including those of academics, research institutes, government departments, industry and commerce.

6.7.3 SuperJANET -- a test-bed for advanced networking

The SuperJANET network will be able to transmit information up to 100 000 times faster than the standard telephone work. In the initial phase of the project, SuperJANET will link sites at Cambridge and Manchester University, Rutherford Appleton Laboratory, University College London, Imperial College London and Edinburgh University (**Figure 24**).

The network is designed to use the most up-to-date communications technology -- synchronous digital hierarchy (SDH) -- in conjunction with BT’s new Switched Multimegabit Data Service (SMDS).

The network will be an important step in that it will allow universities and research laboratories to develop new, advanced educational and research tools. Though the existing JANET network has been very successful, the emergence of new, more demanding applications require the enhancement of the existing network infrastructure. In addition, it is designed to enable the UK educational and research establishments to feed British industry with the necessary skills and expertise over the coming decade.

SuperJANET is considered to be a unique facility, providing an ideal testbed for advanced networking. The academic community comprises a large and demanding customer base spread over a wide geographic area and users will be able to help test some of the new facilities in a real user environment before they are made more generally available.

6.7.4 SuperJANET summary

BT and the UK academic community will collaborate to develop an advanced broadband switching platform for SuperJANET based on ATM. BT will provide an optical fibre network, together with a range of services to support the development of SuperJANET. The aim is to maximise the number of sites connected and offer a range of access speeds to meet different site requirements. The academic community will help BT to test and pilot new broadband services.

The contract with BT covers the provision of an SDH network serving up to 16 sites and offering access at 155 Mbps and 2 x 155 Mbps, with trunk network performance of up to 622 Mbps. Prior to the availability of the SDH network, the sites will be provided with 140 Mbps PDH capacity. The SDH network will be complemented by a SMDS (Switched Multimegabit Data Service) network offering access initially at 10 Mbps.

The ATM work is expected to start with pilot activities forming part of the March 1993 pilot network. The collaboration with BT will include the study of how the SMDS service could migrate to an ATM platform and the study of how such wide-area ATM services will interwork with local ATM networks.BT also plans to include SuperJANET within its recently announced European ATM trial with public telecommunications network operators (PTOs) in France, Germany, Italy and Spain during 1994.

The following schedule is planned:

March 1993	Provision of 140 Mbps PDH network to six sites to create a pilot network. The academic community's plans for the pilot network include a high performance data network and a pilot ATM network.
September 1993	Extension of the PDH network to serve an additional six sites, namely the Universities of Birmingham, Cardiff, Glasgow, Leeds, Newcastle and Nottingham. A further four sites may be selected for connection to the PDH network at this stage. In addition the PDH sites will be connected to the pilot SMDS network.
November 1993	Provision of the pilot SMDS service to a minimum of 29 additional sites. The sites are still to be selected.
December 1993	Phased introduction of SDH to the sites connected to the PDH network.
Early 1994	Introduction of the full SMDS service to all sites.

6.7.5 SuperJANET pilot applications

The pilot network is intended to stimulate and support a wide range of new applications that can exploit the high performance, multi-service capabilities of SuperJANET.

A meeting of the first mix of institutions to be linked was held in July to identify possible application areas that could exploit the pilot network. A second meeting in October discussed a range of project proposals.

In addition to supporting the specific applications, the pilot network will also aim to provide a high performance infrastructure for general use by the six sites and, indirectly, for a wider community. The pilot network will interconnect existing site facilities, such as site FDDI networks, and interconnection with JANET will also be provided. The pilot should be capable of supporting, for example, general use of inter-site X-Windows and some inter-site video communication. The video capability could be used to promote a range of collaborative activities, such as shared lectures and seminars and video conferencing.

The current range of pilot applications is summarised below.

6.7.6 Teaching

It is expected that SuperJANET will support a wide range of teaching and learning activities. University College London has unique facilities to pilot the use of SuperJANET for teaching surgery via interactive video. It is proposed to set up a series of surgical demonstrations between University College London and other centres on SuperJANET. This could support a range of interactive activities including surgical demonstrations from the operating theatre, clinical demonstrations in the lecture theatre, discussions between surgical specialists, the co-operative preparation of video teaching material, and exploration of ways of issuing existing courseware designed for self-directed learning in a distance learning environment. The teaching of surgery, and most medical topics, are heavily dependent on transferring visual information, both static and moving. Changing patterns in hospital training are reducing the variety of patients available to teaching centres. The use of interactive video and the sharing of facilities will in future be required to provide students with the required range of information. The proposal has the support of the departments of surgery at St. Mary’s Hospital Medical School (Imperial College) and the universities of Edinburgh, Glasgow, Manchester and Cambridge.

Supercomputer data visualisation and interaction

Supercomputers are capable of generating enormous amounts of data and in many applications the data can only be understood by the user if it is presented as an image, often using colour and animation. The following are examples of supercomputer applications which SuperJANET can be used to support.

Molecular modelling

SuperJANET will display on a remote workstation the real-time output of quantum mechanical computations running on the Cray YMP at Rutherford. The displays will include bending patterns of molecules, vibrational modes and electron density maps. The pilot will help to determine what kinds of visualisation are feasible over a side-area network. A successful outcome could result in several other university-based computational chemistry groups wishing to use similar techniques.

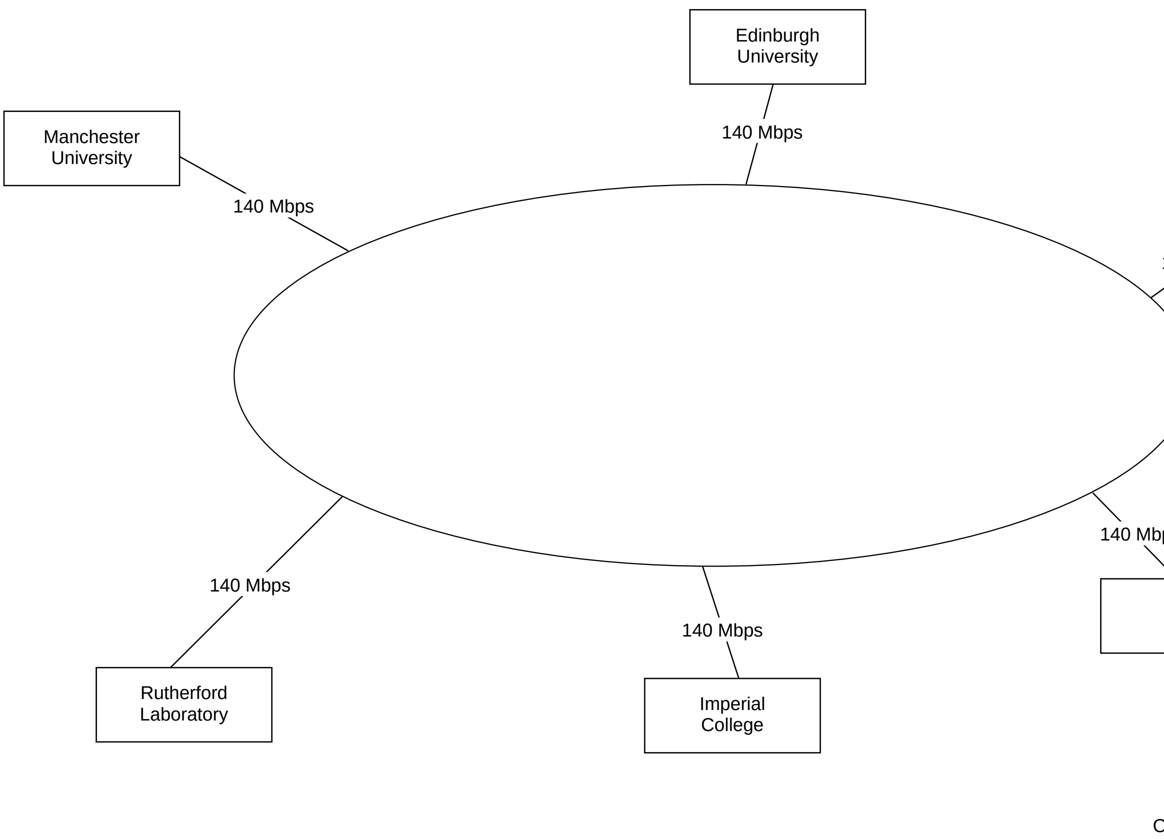
Oil reservoir studies

The visions fingering technique can be used to study the recovery process that may be applied in North Sea oil reservoirs. The application will demonstrate how SuperJANET performance could be exploited to provide a quality remote visualisation package for the interactive modelling and investigation of viscous fingering. This could be of significant interest to the oil industry. The application will run on the Connection Machine supercomputer at Edinburgh University.

Computational fluid dynamics (CFD)

The application will demonstrate the use of advanced visualisation techniques in the prediction of flow and combustion in reciprocating engines. Large scale CFD calculations will be performed on the Cray YMP at Rutherford with visualisation output transmitted to Imperial College over SuperJANET.

Figure 24. **SuperJANET pilot network**
March 1993



Several universities are collaborating in the development of a computer model of the earth's atmosphere that will be used for climate research. The software runs on the Cray YMP supercomputer at the Rutherford Appleton Laboratory and the SuperJANET pilot will involve users at Cambridge University. The pilot will demonstrate the rapid viewing of a time series of weather maps generated by the Cray. It will provide the remote user with the ability to select straight line segments on a map and to obtain a display of certain variables in the corresponding vertical plane. A successful pilot is expected to result in requests to use the visualisation facilities at other sites.

Heterogeneous distributed supercomputing facility

This application will use SuperJANET to interconnect two supercomputers of different architectures -- for example, the Cray YMP at Rutherford Appleton Laboratory and the Connection Machine at Edinburgh University -- to form a single computational unit. There is a class of supercomputer applications that can run more effectively if different parts of the calculation can be performed on different types of supercomputers. SuperJANET will provide the high performance data path between the two supercomputers and could also be used to provide access for a user at a third site. The particular application selected for the pilot concerns 3-D image processing and volume rendering of medical datasets. The Edinburgh Connection Machine will be used for data input and 3-D image processing, the output of which will be transferred to another supercomputer via SuperJANET to perform the volume rendering and calculation of isosurfaces. SuperJANET performance will demonstrate that the complete calculation can be performed interactively.

6.7.7 Information services

Library document distribution

The cost of academic journals is rising well above normal inflation leading to subscription cancellations and the failure to provide new titles required for research. The cost of storing paper volumes on a long term basis is also causing serious concern in many university libraries. Resource sharing between institutions is seen as one possible long term solution, but existing inter-library loan arrangements are slow and labour intensive. Document delivery over SuperJANET offers the possibility of a fast and cost-effective service. The project will aim to demonstrate document request and delivery over the network, involving up to seven universities (including two former polytechnics), with a view to establishing a regular service between all UK university sites as SuperJANET connections become available. The project could be extended to cover other forms of document, e.g. theses or electronic graphics. The potential for long-term cost savings in library shelf space is considerable.

Special datasets

The aim of this project is to demonstrate the potential of remote access to special documents for real-time consultation between experts at different locations. An important aspect is the extremely high image resolution required to reflect accurately the contents of the documents. The types of documents used in the initial pilot will include Genizah fragments and illustrated Persian manuscripts held at Manchester University. The British Library has expressed an interest in contributing to the project by supplying very high quality images of some rare items in its collections. An advantage of the technique is to allow convenient and widespread access to rare or precious documents without the risk of damaging the documents.

Electronic journal testbed

It is proposed to create an experimental electronic journal testbed on SuperJANET through the collaboration of a number of publishers, including learned societies, university publishers and commercial publishers. Each participating publisher will contribute a body of current journal material in a subject specialism. The journal will have a broad subject base and will have features varying with subject specialism in order to explore fully, and take advantage of, the facilities that SuperJANET provides. The range of issues covered by the project could include, for example, the use in science research articles of mathematics, chemical formulae/structure, graphics, half-tones and micrographs. In the humanities the project could cover the use of colour, musical notation, maps, footnotes, etc.

6.7.8 Remote consultation

Pathology consultation network

The high cost of consultant pathologists makes it difficult, if not impossible, for a health region to employ sufficient pathologists to cover specialised areas. There are, for example, only two or three consultants in the UK covering the pathology of the bone. Pathologists with rare specialisations are often found in universities, and SuperJANET could therefore be an enabling facility to allow university pathologists to provide a consultancy service in rare pathologies for the whole country. The pilot project aims to demonstrate the effectiveness of the concept by linking pathologists to operating theatres via multimedia workstations coupled with microscopes. The transmission of high quality microscope images and audio-video communication between the operating theatre and the remote pathologist will be via SuperJANET. The project is led by pathologists at Manchester University.

6.7.9 Access to remote facilities

Brain imaging

This area is aimed at demonstrating remote access to shared facilities. Techniques are now available which can acquire images of the human brain revealing structure and function in exquisite detail. The volumes of data involved are very large and will become larger. New developments will soon permit, for example, the acquisition of whole brain images every few milliseconds. The MRC Unit at Hammersmith Hospital has several advanced facilities for producing brain images that are of interest to research workers at other sites. In the pilot project, brain images acquired at Hammersmith will be transferred via SuperJANET to the Departments of Psychiatry at Edinburgh University and University College London for analysis, and to the supercomputer centre at Edinburgh University for processing.

Remote sensing data

This project would demonstrate the use of SuperJANET to support inter-site transmission of images of the earth's surface generated by the high performance imaging radiometer developed by SERC and flying on board the ESA ERS-1 satellite. The images are held in a computer database at the Rutherford Appleton Laboratory. The availability of SuperJANET will allow remote users to search and browse the large image files, a style of access that is currently inhibited by inadequate network performance. This requirement is particularly important for the Geophysical Data Facility at Rutherford Appleton, which is required to provide satellite imaging data to a number of universities. The user sites involved in the pilot will include University College London and Imperial College, where the classification of cloud images is one particular area of study associated with research into global warming. Other high-quality and high volume geophysical datasets will soon be available and the interactive dissemination of this data to a dispersed user community is a very important requirement that SuperJANET can support.

6.7.10 Group communication

Pandora

This application will aim to demonstrate the potential of a set of networked advanced workstations to support group communication from the users' desktops. The Pandora workstation, developed by the Olivetti Research Laboratory in Cambridge, is a state-of-the-art multimedia workstation capable of video, audio and data communication. It is used within the Olivetti Laboratory and Cambridge University. SuperJANET will enable the workstations to be used between widely dispersed sites. The project will also investigate the potential of interconnecting multimedia workstations to studio type audio-visual facilities used for video conferencing and distance learning. It is proposed to use SuperJANET to interconnect the Pandora network at Cambridge to the University of London video network via University College London.

Collaboration between physicists

This application will seek to demonstrate the use of SuperJANET to support collaboration between high energy physicists at several sites. The activities supported will include sharing of graphics by two remote users, sending images such as oscilloscope traces, to remote engineers, sharing of lecturing loads, and using a distributed file system.

Demonstration of collaborative research and teaching

One of the Grand Challenges of chemistry is understanding the three-dimensional structures of complex molecules and how they interact with smaller molecules, such as drugs and metabolites. Recent advances in workstation development, coupled with the availability of SuperJANET, provides the opportunity for sites to collaborate in providing new facilities in this area. The project will use computerised multimedia facilities developed at Imperial College to create a distributed multi-site facility to support collaborative research and teaching in molecular chemistry.

ANNEX: MEMBERS OF THE OECD-ICCP HPCC RESEARCH TEAM

USA	Kenneth Flamm, Brookings Institution, Washington D.C.; David Farber, University of Pennsylvania, Pittsburgh, Penn.;
JAPAN	Shoichiro Asano, NACSIS, Tokyo; Kazuo Ito, Electronics Policy Division, MITI, Tokyo; Isao Shimizu, Association for Promotion of New Generation Network Services, Tokyo; Yoichi Muraoka, School of Science and Engineering, Waseda University, Tokyo; Tsuruhiko Nambu, Department of Economics, Gakushuin University, Tokyo.
EUROPE	Federico Carminati, CERN, Geneva; Jürgen Seetzen, VDI, Berlin; Paul Christ, University of Stuttgart, Stuttgart;

NON-SITE COUNTRY PARTICIPANTS:

AUSTRALIA	Michael McRobbie, The Australian National University, Canberra;
CANADA	André Dubois, Department for Industry, Science and Industry, Ottawa;
OECD Secretariat:	Dieter Kimbel, OECD, Paris

NOTES

1. One gigabit equals one billion bits: 10^{12}.

2. Rubbia Report, page 3.

3. Rubbia Report, page 3.

4. See Rubbia Report, *op.cit*., Vol. 1, page 6 and Kawahara, K., Dynamics of Fluid Motion, Tokyo, 1992.

5. See Gartner Group, Inc., HPCC: Investment in American Competitivity, quoted from Rubbia, and also ICCP No. 30, Information Networks and New Technologies, pp. 23-27.

6. See: Grand Challenges 1993, The FY 1993 US Research and Development Program, *op. cit*., p. 16.

7. See "A Brief Description of the CNRI Gigabit Testbed Initiative", (CNRI), Washington DC, January 1992, p. 8.

8. For a more detailed discussion see also Chapter 5.

9. Note that one teraflop = 1 000 gigaflops; one gigaflop = 1 000 megaflops; one megaflop = one million floating point operations per second.

10. Note that one terabyte = one million megabytes, one megabyte = one million bytes, and vast amounts of additional storage.

11. For further details see: Khaki Hishinuma, Switching Technology for Broadband ISDN, Executive Manager, Research Planning Department, NTT Communication Switching Laboratories, in Japan Computer Quarterly, No. 91, 1992.

12. See also *Financial Times* of 26 May 1993.

13. See *Financial Times* 13 April 1993.

14. Gopher: originally a colloquial US term for an assistant who runs errands: and WAIS (wide area information server), applications demonstrated to the OECD expert group at Cornell University at Ithaca, N.Y.).

15. See The 1993 Forum Engelberg: Energy and Environment: A Question of Survival.

16. *Source: Status Report on the European Gigabit Initiative, op.cit*., page 47.

17. On European networks, "CEC Whitepaper on Growth, Competitiveness and Employment", *Financial Times*, 10 December 1993.

18. Gartner Group, in: Rubbia, *op. cit*., page 7.

19. For example, the Vice-President of the US, Albert Gore, when introducing the National High Performance Computer Technology Act, stated: "the nation which most completely assimilates high-performance computing into its economy will very likely emerge as the dominant intellectual, economic and technological force in the next century".

20. See M. Porter, *The Competitive Advantage of Nations*, Macmillan, New York, 1990.

21. See the discussion in Section 1.2 of this report and the objectives of HPCC programmes in Australia, Canada, Germany and the UK.

22. US Bill National Competitiveness Act 1993 in the Senate of the United States, 21 January 1993.

23. See also: Testimony of Robert Allen, Chairman and CEO, AT&T before the House Subcommittee on Telecommunications Finance, 24 March 1993.

24. See Status Report on the European Gigabit Initiative, R. Popescu-Zeletin, Berlin, p. 31.

25. Rubbia Report, Geneva, October 1992, p. 11.

26. For details see footnote 27.

27. For Europe, this feature has also been requested by D. Faber, University of Pennsylvania, USA and R. Huber, Commission of the European Communities, DG XIII, in their presentation at the 2nd International Broadband Islands: Bridging the Services Gap Conference, Athens, 15-16 June 1993.

28. See Programme on Next Generation Optical Fibre Network, Bill under preparation for Diet approval in June 1993.

29. Cost-based tariffs in N- and B-ISDN: or the potential for decreasing tariffs:

    1. The potential transmission rate of glass-fibres and ATM switching (B-ISDN) which is at least about 1 500 times the digital transmission rate in normal copper wires of the plain old telephone (POT) in the N-ISDN could lead to considerable cost reduction for normal narrow-band communications, i.e. telephony and document (data) transmission. The provision for this reduction is that the investment cost for broadband system for the subscribers are only about 10 to 25 times of the POT system.

    2. We calculate a very simple case in order to explain the basic considerations:

        -- Take a group of 100 users (one middle-sized establishment or a group in a larger establishment occupying one B-ISDN line in the future). The average POT usage cost of this group may be 60 000 ECU/a. 100 users (persons) and 200 workdays per year (100*200/wd*pers.) would use the POT system for 3 ECU/wd*pers. This could correspond in Germany to 4 units @ 0.125 ECU local calls and 20 units for long distance calls. This would occupy the line for 34 min./pers. 34 min. are 1.8 10^3 = 1.15*10^8 bit/wd*pers. or 115 Mbit/s this would occupy the system by only 1.15 s/wd*pers. Take a tariff in the B-ISDN system of 150 ECU/h and a basic tariff of 20 000 ECU/a, the former POT usage would be reduced to (150/3 600)*1.15 = 0.05 ECU/wd*pers. plus 20 000/20 000 = 1 ECU/wd*pers. which is 1.05 ECU/wd*pers. compared to 3 ECU/wd*pers. Of course, the tariffs can be set otherwise and the relation between the fee for N-ISDN and B-ISDN would be respectively different. But the basic argument holds that in the B-ISDN the former N-ISDN services can be substantially cheaper.

    3. This then could lead to a remarkable increase in generic broadband usage as point to point or multipoint video communications, or co-operative design, or co-operate decision making, or document retrieval. This could lead to an occupation of the B-ISDN line per person to about 2 min./wd*pers. in the future which corresponds to 120 min./m video conferencing per person and month provided the 100 Mbit/s transmission capacity can be split into parallel lines of about 35 Mbit/s video telephony.

30. This chapter is based on a contribution from Prof. Michael McRobbie, Australian National University, Canberra, Australia and Member of the OECD Research Team on HPCC.

31. For further details see: "Switching Technology for Broadband ISDN", Chiaki Hishinuma, Executive Manager, Research Planning Department, NTT Communication Switching Laboratories, in *Japan Computer Quarterly*, No. 91, 1992.

32. TCP = **T**ransmission **C**ontrol **P**rotocol; IP = **I**nternet **P**rotocol.

33. See The 1993 Forum Engelberg: Energy and Environment: a Question of Survival.

34. The investigation held in Tokyo from 20-23 July 1992 was conducted by 11 participants from the United States, Canada, Germany, Switzerland, Australia and Japan. The schedule of meetings included:

20 July	Morning	Discussions at MITI
	Afternoon	Discussions at MPT
21 July	Morning	NTT Yokosuka Research Centre
	Afternoon	Demonstrations and discussions at NTT Yokosuka Research Centre
22 July	Morning	Presentations at Fluid Dynamics Research Institute
	Afternoon	Presentations on RWC ETL (MITI), Tsukuba City
23 July	Morning	Presentations at NACSIS
	Afternoon	Summary discussions at NACSIS

35. CII -- Centre for the Informatisation of Industry, located in the Japan Information Processing Development Centre (JIPDEC).

36. CCITT -- Consultative Committee for International, Telephone and Telegraph, an arm of the International Telecommunications Union (ITU). Following the reorganisation of ITU, CCITT's responsibilities for standards is now with the Standardisation Sector of the ITU.

37. CNRI (Corporation of National Research Initiatives) has been mandated to lead and analyse the five Gigabit Testbeds; for further details see: A Brief Description of the CNRI Gigabit Initiative, CNRI, Washington DC., January 1992, and Status Report on European Gigabit Initiatives, Professor R. Popescu-Zeletin, Berlin 1993.

38. For further detail see: A brief description of the CNRI Gigabit Initiative, CNRI, Washington D.C., January 1992 and status report on European Gigabit Initiatives, Prof. R. Popescu -- Zeletin, Berlin 1993.

39. SIMD machines consist of a control unit to broadcast the instructions to be executed, a number of processors (each executing the same instructions), a number of memories and an interconnection network. A machine consist of a number of processors (each executing different instructions), a number of memories and a network. The two style of parallelism differ in that the processors in NIMD operate asynchronously with respect to each other unlike the synchronous operation of processors in SIMD. This results in the MM system having increased flexibility, however, at the cost of increased overhead and program complexity.

40. Report compiled by the OECD Secretariat.

41. By Prof. Risto Nieminen, Helsinki; Presentation at EIIT meeting in Paris.

42. By Dr R. Cooper, Rutherford Laboratory, UK; Presentation at site visit in Berlin, 26 October 1992.