Data Networking for the European Academic and Research Community

Is it important?

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Executive Summary

The paper starts with a review of data networking, and makes various comparisons between data networking and other, more conventional, communications systems. Data networking is a fast growing field that is likely to be vital for industry and commerce, as well as for academic and research users.

In the USA data networking services are normally considered to have started in about 1975 with the ARPAnet, which linked establishments working on non-classified defence research. This has now evolved into the Internet, which is regularly used by more than 2 million users. There is a strong political push to emphasise high performance computing and communications as a basic component of the national competitive advantage. This has led to the planning for the National Research and Education Network, or NREN.

One very noticeable feature of American data networking is the strong collaboration that exists between the three major suppliers of long-distance voice and data lines (the "common carriers"), namely ATT, US Sprint, and MCI, the regional telecoms operators, the regional and national network organisations, research institutes, universities, computer companies and government agencies.

In Europe today we can find a number of data networks, national or international, single- or multi-disciplinary, that provide very valuable service to their academic and research users. But these data networks are only a pale shadow of what is available to the American academic and research community. Unfortunately, data networking seems to be planned and operated in Europe on a country-by-country basis, and the pan-European strategy and infrastructure are missing. The authors are convinced that Europe is in the process of abandoning, almost by default, a vital segment of tomorrow's commercial and industrial base to our competitors.

The barriers to progress in Europe include the regulatory situation of European telecoms; excessively high tariffs for leased lines; the absence of pan-European suppliers of leased lines; the very conservative approach to telecoms adopted by European industry, PTTs, and the European Commission's DGXIII and related parties, all of whom underestimate the intimate relationship between workstations, computers and data networking; the lack of fully European scientific computing companies with which to collaborate; various issues related to networking protocols; an absence of wide collaboration between industry, government, the PTTs and the research and educational community; and finally the absence of a strong focus for European networking, such as is provided by Washington in the USA.

This list of the barriers to progress shows that the "problem" of European data networking is not a simple one. There are, therefore, no simple "solutions", but progress will only come if we can improve the understanding of the issues among Europe's politicians, industrialists, PTTs, network providers, and network users, and subsequently improve their collaboration.

After some reflection the authors offer the following suggestions as elements for building a consensus on the way to make progress.

• One key element must be to provide a stronger focus for academic and research networking at the pan-European level. Some small group of people must feel that they "own" this problem, and must be given the authority, responsibility and means for making progress.
A second key point is that we need to give a stronger emphasis than in the past to the service needs of the academic and research users. They want high-performance and high-quality data networking services today, and they are willing to pay reasonable prices for them. These services should be based on a commitment to non-proprietary Open Networking protocols, including TCP/IP and OSI.

The third key point is that we must build in Europe the sort of collaboration in the field of data networking that can be observed in the USA, involving government, industry, the common carriers, and the academic and research community.

While there were good historical reasons for founding EARN and RARE as separate organisations responsible for different aspects of European data networking, we feel that these reasons are no longer valid, and that they should now be asked to merge as quickly and as equitably as possible. At a stroke this merger would radically improve the European focus on data networking.

In the coming months, RARE, or preferably the merged EARN/RARE, should be encouraged to set up its planned operating agency. In our view this should initially concentrate on providing a service for the operation of the pan-European leased lines used for all academic and research data networking, whether national or disciplinary. If this is to be successful, the goals of the operating agency must be to satisfy the needs of all users and to provide a high quality of service, so that all of the existing operators will automatically want to use this service. As mentioned above, the service must support all Open Networking protocols.

RARE, or again preferably the merged EARN/RARE, should itself concentrate on long-term planning and policy issues, and leave day-to-day matters to the operating agency. Again, it must worry about the infrastructure needed for data networking for the whole of the European academic and research community, defined in the broadest sense. The commitment of RARE users must be to expand the use of non-proprietary Open Networking everywhere in Europe.

In the medium term (2-3 years) the authors would like to see RARE evolve into a European Treaty Organisation with the mission to plan and oversee the operation of Europe's data networking infrastructure. We refer to this as the European Data Network Agency (EDNA). Membership of such an agency would be open to all European countries, whether from the EC, EFTA, central and eastern Europe, or elsewhere. The Agency would provide a good forum for future planning and the fact that it was a treaty organisation should ensure that it receives enough high-level political and industrial attention. It should keep its own staff numbers at a low level, and aim to use commercial services as soon as the requirements for those services are clearly understood, but not before.

Despite the really frustrating lack of progress over the past few years towards creating a viable pan-European infrastructure for data networking, all is not lost. Provided we clearly identify the problems that are facing us, and decide how they should be tackled, Europe certainly has the skills, the industrial strength, and, we hope, also the will, to make the necessary breakthroughs. However, if we do nothing the authors are convinced that European data networking will remain underdeveloped in the short term, and will then quickly be colonised by companies based in the USA who have understood the developments needed in this fascinating market, which is so full of opportunity for progress and profit. Put bluntly we will have abandoned European data networking to some combination of American computing and networking companies.

We are convinced that data networking is an emerging industry where Europe is almost absent. We believe that industrialists and politicians must be given this vision, and then encouraged to take appropriate action. We need to obtain a commitment from all influential people and bodies for an urgent programme to build a solid pan-European infrastructure for data networking.
Data Networking for the European Academic and Research Community

Is it important?

1. Introduction

The authors of this document are responsible for some aspects of data networking for the European academic and research community, so it is perhaps not surprising that they believe that it is an important topic. However, they are concerned that it is important not just for the health of the research community itself, but that it will be vital for the future industrial and commercial strength of Europe. It is to try to convey the arguments behind this wider view of the importance of data networking that they have produced this note, which they hope will be read by industrialists, politicians, journalists and civil servants, and maybe even by specialists in data networking.

2. Disclaimers

The ideas presented here should be considered to represent the authors' personal views, and not to constitute any official position of their employer. The authors have endeavoured to check all facts, and to clearly separate opinions from facts. They have written this note as a positive contribution to an ongoing debate on a complex subject, and wish to make it clear that, even if they sometimes express criticism of past or present policies, this should not be taken in any way as criticism of the individuals or organisations who formulated those policies. They are interested to take part in any future discussions on the topics raised, preferably with a view to making concrete progress.

3. Data networking

In this chapter we aim to give a rapid introduction to data networking, and to briefly compare it to some other forms of communication. The chapter may profitably be skipped by readers with sufficient background.

3.1. Definitions and different aspects

For the purposes of this discussion we define data networking to be the transmission of data from one desktop workstation to another. Here we are using the term "desktop workstation" rather loosely to cover both real workstations, and personal computers, and even "dumb" terminals attached to a server computer, as long as the device concerned is installed at the user's normal place of work and not shared with other people.

While the users of the two communicating workstations will often be working for the same institute or company and located in the same building, they will also commonly work for different institutes or
companies, and be based in different buildings, or at different sites, or even be located in another country or continent.

Simplifying a little, we can identify four major components of data networking that are crucial for the academic and research community, namely:-

1. Electronic mail;
2. Sharing expertise (news groups);
3. Sharing documents and data;
4. Remote access to resources.

3.2 **Electronic mail**

In order to share expensive facilities and to avoid duplication of effort, the academic and research community has to have an international outlook, and it frequently needs international data networking in order to collaborate effectively. Let us first examine the benefits of electronic mail in that environment.

- **Sender and receiver never in office at same time**

Academic and research staff spend much of their time out of their offices. Even ignoring time spent in meetings or travelling, scientists spend considerable periods in laboratories, and literary and historical researchers need to study manuscripts in libraries. The consequence is that two people needing to exchange information are rarely both in their offices at the same time. A major advantage of electronic mail is that it is delivered to the user's desktop and s/he can read it at a convenient moment, and does not need to be interrupted to take a telephone call at an inconvenient time. Furthermore, if the sender and receiver decide that they need to converse by telephone (because they need an interactive discussion) then they can use electronic mail to agree on a mutually convenient time.

- **List handling**

If researchers are working in a small team then it is trivial to keep a list of their electronic mail addresses so that all members of the team can receive messages that are intended for "broadcasting", whether they are simply spreading information, or soliciting input, such as trying to fix the time for a meeting.

- **Time zone effects**

Traditional (surface or air) mail has always allowed the sender and receiver to read and write their messages at times of their own choosing. However, the time required to pose a question and to receive a reply is several days inside a small country, and up to many weeks across the globe. This is so slow that it excludes most effective sorts of working collaboration. On the other hand, while telephone connections offer the prospect of an immediate response, they suffer from time zone effects. These are merely annoying for communications inside Europe, but
become a major problem for contacts between Europe and the USA (especially the West Coast) or between Europe and Australia or Japan. Electronic mail is typically delivered inside the same country in less than 5 minutes, and in less than 30 minutes across the world. So provided that both partners read and react to their electronic mail a few (1-3) times per day they can collaborate effectively even though they are based in very different time zones.

- **Easy to reply and forward**

Since the messages are delivered to the receiver's workstation s/he can reply easily. Non-urgent questions can be replied to with a minimum amount of typing at some quiet moment of the day. Incoming information that should be distributed to, for example, all heads of section, or all members of a group, can be forwarded extremely simply. Furthermore queries can be extremely easily passed to a colleague in another country or continent who is known to be an expert in the field.

- **Easy to delete short term information**

Information that has a short term validity can be simply deleted as soon as it has been read. In this form it never goes down on paper.

- **Easy to store long term information**

On the other hand information that may have long term value can be moved into whatever filing system the sender or receiver (or their secretaries) finds convenient to use, including paper.

- **Low cost**

While the true cost of a facility that most organisations treat as infrastructure is not easy to determine, it seems clear that sending ten lines of electronic mail costs much less than one tenth of the cost of an equivalent phone call. The fact that the sender and receiver can deal with their own electronic mail may sometimes reduce their need for secretarial support, further driving costs down, and this can be an especially important consideration in the academic and research community.

3.3 **Sharing expertise (news groups)**

Modern science and technology progress continually, and at a very rapid pace, and there is a constant battle for the people concerned to keep up-to-date in their own fields of speciality. Data networking has proved to be very useful in this respect, by permitting the formation of various "news groups" or "bulletin boards". Each "news group" provides many items of technical information which are updated on a daily basis, and allows participants to pose questions related to the topic of the "news group" and quickly receive valuable answers from several of the world's experts in that field, who will be regularly scanning the "news group". It is impossible to know precisely how many of these "news groups" are in existence,
but the most popular service aimed at professionals deals with some 1500 topics.

3.4 Sharing documents and data

People working in a team need to share documents. These documents may be traditional documentation, such as project plans, schedules or reports, or they may be dynamically developing items such as computer programs or data. Data networking, when operated in conjunction with suitable management software in their workstations, allows several people to share access to such documents in a coherent way. At present this sort of sharing is most effective for documents that are entirely textual in nature, including almost all computer programs or scientific data. However, as multi-media workstations (see below) become common, effective sharing of more complex documents will also become possible. This development will certainly widen the area of applicability of collaborative data networking.

3.5 Remote access to resources

Another way in which data networking can be used is to provide access, for someone using a desktop workstation, to remote resources. These resources might be, for example, a specialised computer system where the person wishes to make calculations or manipulate graphical images, or a database where the person wishes to make a search for information.

3.6 Computing as a utility

By now it is common knowledge that computing has moved from the closed world of the mainframe to the wide open world of "distributed computing". It is clear that data networking has been and will continue to be at the heart of this development, since it is the technology that has enabled easy access from the desktop workstation to information in its most general sense.

One model that is now receiving attention in America is the concept of the "information and computing utility", which would provide the user with access to data and computational resources through a single "data network" plug in the wall. We emphasise that, even though this model is speculation about the future, remote access to resources, electronic mail, news groups, and the sharing of documents and data are all well understood data networking tools which are available and much used today throughout the academic and research community.

3.7 The influence of fibre optics

Fibre optic technology allows for the very reliable and fast transmission of data along very thin optical fibres. While costing substantially the same as copper cabling to buy and to install, it has a very much higher capacity. Enormous progress is still being made in increasing the amount of data that can be transmitted along each single fibre, and this progress is really driving down the underlying costs of data networking in a very dramatic
manner. It is also serving to blur considerably the distinction between
data and voice networking, since the cheapest way to transmit voice traffic
is now to digitise it at source and to regenerate it at the ultimate
destination.

It also has to be mentioned that existing transmission technology used to
drive fibre optic communications only exploits a tiny fraction (less than
one part in ten thousand) of the theoretically available capacity. Specialists
feel that they understand how more and more of this capacity can be
exploited, at reasonable cost, in the future, and this explains why there is
so much confidence that the underlying costs of data networking will
continue to plunge. In addition people are starting to produce prototypes
of "fully optical" switches, which might be at the origin of further
breakthroughs.

3.8 Satellites

Satellite transmission provides an alternative to fibre optic, or other, more
conventional, data communications lines. It has some interesting advant-
eges, including the possibility to distribute one message to multiple
destinations (multi-casting), and to reach sites in areas with poorly
developed data communications infrastructures. There are some disad-
advantages, including the roughly half-second of delay that is introduced
by the long round trip to a geostationary satellite, and which is a severe
nuisance in interactive data network applications.

In the USA, small satellite dishes known as Very Small Aperture
Terminals (VSATs) have been used in several appropriate applications,
including the linking of company headquarters to dealer and repair
networks. In Europe the market is heavily regulated, almost entirely
under the de facto and/or de jure control of the PTTs, and little developed.

With the possible exception of applications that are able to exploit the
multi-cast nature of the medium, we tend to doubt that satellite
transmission systems will be a major element in future academic and
research data networking. But we recognise that we might well be wrong.

3.9 Relations to other sorts of networking

In the following sections we discuss the relation between data networking
and some other types of networking which may be more familiar to our
readers. Each type of networking has a preferred area of application.

• Fax

The widespread introduction of facsimile machines having the ability to
send documents from place to place across the telephone network was a
truly revolutionary progress. When comparing data networking,
including electronic mail, to fax we can note the following:--
1. Both methods are fast, avoid the need for both sender and receiver to be available simultaneously, and avoid time zone effects.

2. The major difference today is that electronic mail delivers text from one desktop workstation to another, while fax delivers an image (often of text) from paper (or sometimes from a desktop workstation) to paper.

3. Processing a fax (forwarding it, manipulating it, storing it) is an operation that is much more labour intensive and error-prone than processing an electronic message that has already been captured as text and delivered to a workstation.

4. Because text is much more compact than a digitised image of the same text, fax is considerably more expensive to transmit than electronic mail.

5. Fax is less well adapted to group communications, since the typical fax machine makes the transmission of the same fax to some twenty different people a very labour-intensive and error-prone activity.

6. On the other hand fax is undoubtedly the preferred method, today, for disseminating graphical information, or text written in non-latin alphabets, or, more generally, any information that has been recorded solely by hand or by typewriter.

- Voice telephony

Voice telephony has been with us for a long time, is extremely widespread, and is not going to disappear because of the arrival of any upstart systems, such as electronic mail or fax. Above all voice telephony is essential when the parties need an interactive dialogue. It is difficult (though not impossible!) to have a violent argument by electronic mail. Compared to data networking, voice telephony is rather expensive, requires both parties to be simultaneously available, and is not very efficient for the unambiguous (error-free) transmission of factual information. We feel that it should be reserved for those occasions when it is really appropriate.

- Videoconferencing

Videoconferencing allows a group of people to conduct at meeting "at a distance". Typically two groups sit in well-equipped studios with video cameras and microphones, linked by communications lines, and each group can see and hear the other. The general experience is that the quality of the transmission, and especially the quality of the sound systems and overhead projectors, is critical to effective videoconferencing. We tend to feel that ubiquitous systems, such as multi-media workstations (see below), are likely to be more successful than dedicated videoconference systems which require the users to reserve facilities well ahead of time and move to well-equipped studios. However, we note that videoconferencing systems and data networks can very well share the use of any communications lines that offer sufficient capacity.
• Audioconferencing

"Conference calls" allow several people to take part in one multi-way telephone conversation. This approach obviously demonstrates all of the various advantages and disadvantages of voice telephony, discussed above. In addition, it is sometimes hard for all listeners to correctly identify who is speaking at any given moment. Audioconferencing is, of course, much cheaper, and potentially much more widely available, than videoconferencing.

• Videotext

The French Minitel system is an excellent example of videotext technology, and its successful introduction into the mass market certainly carries several lessons for European governments and industries. There are two main contrasts between videotext systems and data networking of the type we have been describing:-

1. The main model of videotext is that the user has a "dumb" terminal in the home (or office) and not an intelligent workstation. Information is supplied, sometimes free and sometimes at a price, from a server computer to the user's terminal. So videotext concentrates on the fourth component of data networking described above, namely remote access to (information) resources, with much less emphasis being given to electronic mail and the sharing of documents or data, which are more productive for users that have access to an intelligent workstation rather than to a "dumb" terminal.

2. The bandwidth available with most videotext systems is rather low, and therefore entirely unsuitable for serious document or data sharing, or for giving access to powerful computing resources.

• Electronic Data Interchange (EDI)

EDI is designed to allow much of the normal operation of business (ordering, invoicing, payment) to be carried out electronically and more or less automatically. It is conceptually a specialised set of applications running on top of widely available electronic mail services linking all of the companies involved. EDI will be a very valuable tool for European industry and commerce when it becomes widely available.

• Multi-media networking

Considerable progress has been made in the last few years towards the creation of workstations that can handle "multi-media" information. This means that, in addition to displaying text on their screens, they are capable of presenting (and sometimes of capturing) high quality graphical, video, and audio information. This information is, of course, all stored in digital form. It now seems clear that these multi-media workstations will start to come onto the market at reasonable prices in the next 6-24 months,
and that their introduction will lead to a further blurring of the distinction between data, image, and voice networking.

Many people believe that multi-media workstations, by enabling the transmission and manipulation of high quality images, will be much used in business and commerce, and are likely to revolutionise business communications in the next few years. In view of the sharply increased amount of data that has to be transmitted, they will also give rise to a strongly increasing demand for bandwidth on data network lines.

4. Situation in the USA

4.1 Present status

• American Internet

Widespread data networking is normally considered to have started in the USA in about 1975 with the ARPAnet, which was a network set up by the Defense Advanced Research Projects Agency (DARPA) to link sites involved in unclassified advanced research funded by the American Department of Defense.

Today we see two forms of data network in the USA, namely the regional networks and the national networks. Regional networks concern themselves with delivering data networking services to interested sites in their region (there are some 25 covering the US) whereas national networks deal with the national connection of some subset of the academic and research community. All of the regional and national networks are linked together under the name "Internet", which is run by consensus among several agencies of the federal government.

Today the Internet links at least 2,500 sites in the USA, including many huge university systems, and it is believed that it connects roughly 300,000 computers and workstations, and is used regularly by more than 2 million academic and research workers.

Proposals have been generated very recently for the formation of a learned society, to be known as the Internet Society, which would aim to facilitate and support the technical evolution of the Internet on a world-wide basis.

4.2 Current developments

There seems to be a considerable consensus in the USA that advanced computing and advanced networking are going to be key factors in determining the future economic health of the country. While the support of Senator Al Gore Jr. (Democrat of Tennessee) has been very important in building this consensus, the High Performance Computing and Communications Initiative is now being pushed directly by the White House. One result is that plans are now well advanced to make major developments in data networking for the American research community.
National Research and Education Network (NREN)

The following text is taken from "Grand Challenges - High Performance Computing and Communications" a supplementary document to President Bush's FY 1992 Budget.

The National Research and Education Network (NREN) component of the High Performance Computing and Communications (HPCC) Program dramatically expands and enhances the U.S. portion of an existing worldwide infrastructure of interconnected computer networks called the Internet. A substantial fraction of the domestic Internet is supported and loosely coordinated by Federal agencies, principally the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), the National Aeronautics and Space Agency (NASA) and the National Science Foundation (NSF).

Collaboration among scientists is an important and integral facet of the U.S. research environment. It can be greatly improved by increasing the level of network connectivity and by introducing new capabilities into the existing infrastructure. The NREN design will not only address broad network connectivity, but will also provide the basis for necessary higher level capabilities and services.

Many educational institutions, government laboratories, and industrial research facilities are currently connected to the Internet. Yet, it still falls short of a widespread, uniform, and high performance national infrastructure. In order to satisfy the HPCC Program goals, the NREN must not merely provide network access to research and educational institutions at all levels and locations, it must also deliver new capabilities. Some of these, such as distance learning, may initially be extensions of current technology. All capabilities will benefit from, and many will be enabled by, a program of research into very high speed technology. This technology is needed to support access to digital libraries, large scale distributed computing resources, as well as to perform computationally intensive applications that require real time visualization of modeling and simulation results, rapid interrogation and retrieval of scientific data from specialized data bases, remote control of experiments and simulations, and teleconferencing.

In addition to serving the needs of the scientific and research communities, the NREN will provide valuable experience necessary for the successful development of a broader privately-owned national information infrastructure. Such an infrastructure would allow consumers, businesses, and schools and government at all levels to share quality information and entertainment when and where they want it at a reasonable cost.

[.........]
The vision of the NREN is of an interconnection of the nation's educational infrastructure to its knowledge and information centers. In this system, elementary schools, high schools, two and four year colleges, and universities will be linked to research centers and laboratories so that all may share access to: libraries, databases, and diverse scientific instruments such as supercomputers, telescopes, and particle accelerators. The NREN enables communication and fosters collaboration among and within these communities. By reducing the traditional impediments of geographical isolation, the NREN improves the quality and raises the level of education nationwide. The NREN contributes to the success of the Basic Research and Human Resources component of the High Performance Computing and Communications Program. By making unique scientific and informational resources accessible beyond their physical locations, it permits widespread participation in the HPCC Program by scientists, university researchers, and students, and it enables the development of large scale distributed computing resources.

End of quote.

• Gigabit Testbeds

Already today the American Internet, and in particular the National Science Foundation backbone network running at 45 Megabits per second (which represents a speed-up by a factor of 800 since 1987) is an impressive precursor of the future National Research and Education Network. As part of their investment in the future, DARPA and the NSF have sponsored five Gigabit Testbeds, in order to start intensive Research and Development into the speed range (Gigabit per second networking) that will be required in 1994/95.

The US government funding for the five testbeds is planned to amount to almost 16 M$ over a period of three years, but the industrial partners mentioned below are effectively contributing several times as much.

• Collaborations

One of the most noticeable features of American networking developments, in particular the Gigabit Testbeds just mentioned, is the strong collaboration that exists between the three major suppliers of long-distance voice and data lines (the "common carriers"), namely ATT, US Sprint, and MCI, the regional telecoms operators, the regional and national network organisations, research institutes, universities, computer companies and government agencies. This is quite unlike the situation that we can observe in Europe.

• Start-up businesses

There are at least three areas where new businesses are being started in connection with American data networking.
1. The roughly 25 regional network operators see themselves as in the business of supplying data networking services to their local community of potential clients. While the majority of these operators declare that they are "not-for-profit" (a status which affords them some tax privileges), one or two have openly declared that they intend to make money.

2. The technology needed to interconnect computers with data communications lines is leading to the creation of new high technology start-up companies. Cisco (sic) is one such example, now employing close to 500 people, having an annual turnover approaching 200 M$, and selling hundreds of boxes to Europe.

3. At least one company, Advanced Network Services, has been founded (with an ex-IBM Vice President playing a prominent rôle) to enter the business of data networking, initially for the academic and research community.

   - Move into schools

   The NREN does not limit itself to universities and research institutes, but has well developed plans to connect up all American schools, secondary and even primary.

   - Move into business

   There is a long tradition in the USA that the research departments of high technology companies have had access to the Internet. This is extremely valuable for collaborations between these departments and universities and research institutes, which are clearly useful, for example, for the rapid evaluation of new product developments - where time to market with a quality product is such an essential factor to success in today's competitive situation. Within the last six months the internal networks of Digital, Hewlett Packard and IBM have become fully interconnected to the Internet, and many of their employees can now be reached by that path.

5. Situation in the Pacific region

5.1 Present status and developments

We are so used to believing that Japan is forging ahead in computing that it comes as something of a shock to realise that they are well behind the USA, and maybe even Europe, in the field of data networking for the academic and research community. There seem to be no high speed lines, with a capacity greater than 64 Kilobits per second, in use. However a national coordinating committee was formed some months ago, and there are signs that the Ministry of International Trade and Industry (MITI) is starting to focus its attention on data networking. Other countries such as South Korea, Hong Kong, Australia and New Zealand seem also to have taken steps recently to improve their data networking infrastructure, and in the last few months a committee has been set up to coordinate academic and research data networking in the whole of the Pacific region.
On a more positive note, NTT have well developed plans for a Gigabit Testbed project linking their Musashino and Yokosuka research laboratories by 1993. In addition, Fujitsu have already presented their very interesting plans for high speed fibre optic technologies, capable of switching traffic both in the local area and over long distances, to some of the interested standardisation bodies. In general Japanese industry is strong in basic fibre optic technology, and Hitachi and other companies are also known to be active in developing switches for very high speed fibre optics.

6. Situation in Europe

6.1 Present status

- National networks

Many, but not all, European countries have a national data network for use by their academic and research community. These networks are typically based on leased lines supplied by the national PTT, and the operation is often the responsibility of a small team set up specially, and reporting to the ministry responsible for research or education. The universities and research institutes attached to the network typically pay an annual fee to cover most or all of the operational costs. In view of the high cost of European leased lines it is still unusual to find any individual university or institute that has a connection bandwidth exceeding 64 Kilobits per second (Kbps), with the exception of the UK, where tariffs are slightly more reasonable. We would like to point out that 64 Kbps is less than 1% of the bandwidth offered by an Ethernet, which is one of the Local Area Networks most widely used to connect desktop workstations.

- Disciplinary networks

There are some scientific disciplines which have a tradition of operating on a pan-European level. These include weather forecasting, particle physics, and space science, all of which have an associated European Treaty Organisation (the European Centre for Medium Range Weather Forecasting - ECMWF, the European Laboratory for Particle Physics - CERN, and the European Space Agency - ESA, respectively) which acts as the main source of data and a natural pole of communications.

Since no pan-European networks of the required performance existed, all of these disciplines have set up their own disciplinary networks, which they pay for and operate. Of course, there is strong collaboration with other networking organisations, both in Europe, where the cost of leased lines is often shared, and for the intercontinental lines.

- EARN, EUNET, RARE and COSINE

When the historians come to write the story of European data networking they will have to review the formation and growth of at least four organisations that see themselves as working towards inter-
disciplinary, inter-country data networking in Europe, namely EARN, EUNET, RARE and COSINE. We only have the space for a very brief overview.

◊ EARN

The European Academic and Research Network - EARN - was sponsored by IBM in 1984, as soon as it was clear that a similar organisation in the USA (BITNET) was proving to be a success. It was based on the idea of having one site per country, normally a major academic computing centre operating on a 168 hours/week basis, acting as a national EARN hub. All other sites in that country were only required to lease a (typically low speed) line to the national hub in order to join the EARN network. The major costs, for leasing the higher speed international lines connecting the national hubs, and for supporting a small operations staff, were paid by IBM during the first few years.

EARN has evolved into an organisation that can be described as IBM-flavoured, but it is important to understand that it is not IBM-exclusive. The majority of its funding now comes from annual fees paid by the institutes that attach to EARN, and roughly 50% of the computers attached to EARN are non-IBM machines, mainly VAXes from Digital Equipment.

An important advantage of EARN has been the fact that its original technology was very robust, and indeed, almost old-fashioned. This has meant that it was very easy for countries in central and eastern Europe, and north Africa, to join EARN and quickly obtain a reliable connection at a reasonable cost. On the other hand this older technology does not allow EARN to offer remote access to the computers on its network.

◊ EUNET

The European Unix Network (EUNET) grew out of a similar body (USENET) in the USA which offered dial-up connections over modems to an informally run network for the distribution of electronic mail and the support of news groups. For some years now it has been run on a rather more formal and professional basis. It offers perhaps two strong features. The first is that it provides access to a very wide and well organised set of news groups, which are of interest to professionals in many diverse fields. The second is the fact that it has been the easiest data network for the research department of a commercial company to join - since USENET and EUNET receive no direct government support there is never any question of their using money that was intended solely for education or research to support commercial activities.

◊ RARE

The European Association of Research Networks - RARE, from its French acronym, Réseaux Associés pour la Recherche Européenne - brings together Europe's national research networks and several other bodies interested in pan-European data networking, and was founded in 1986. RARE has been a key influence on the directions taken in pan-European
data networking, where the output from its technical working groups have been especially significant. It has also acted as an agent for COSINE (see below). Rather surprisingly it has never seen itself as an operating agency for pan-European data networking, but proposals to move in that direction are being actively developed at the present time. The existing RARE statutes give strong emphasis to the use by RARE of OSI protocols (see below for a discussion of protocols).

◊ **COSINE**

The Cooperation for Open Systems Interconnection Networking in Europe - COSINE - was launched as a Eureka project in November 1986, but the project definition, prepared in collaboration with RARE, took a long time to finalise, and the three year Implementation Phase started only in January 1990. As its name implies COSINE is strongly committed to the introduction of OSI protocols in Europe. It is not a network operating agency, but aims to create a set of pan-European OSI-based infrastructure services, by coordinating the efforts of national networks. COSINE was responsible for setting up the Interim X.25 Infrastructure (IXI), which has been providing an X.25 service based on about twenty national access points connected via 64 Kbps lines since mid-1990. While IXI has been useful for some countries with poorly developed infrastructure, its overall success and future funding remain rather uncertain.

• **European Internet**

One of the most surprising developments in European data networking over the past two years has been the explosive growth in services running the Transmission Control Protocol / Internet Protocol (TCP/IP) protocol suite, as used in the American Internet, to create what can only reasonably be called a European Internet. There are now some 100,000 computers and workstations connected to this European Internet, making it by far the largest grouping of the European data networks used for academic and research work. The availability of the open TCP/IP suite on a very wide range of computers and workstations, and the high quality and reasonable cost of much of the related software, and immense efforts going into developments of this software, are all factors influencing this rapid growth.

We should also point out that EASInet, based to a large extent on the use of the TCP/IP protocols, has been a substantial influence on the growth of this European Internet. EASInet ties together some twenty computer centres belonging to the IBM-sponsored European Academic Supercomputer Initiative. It is encouraging for the future of European data networking that a vendor supplying many of Europe's biggest scientific computers has agreed to sponsor a European network based on Open Network protocols (TCP/IP), rather than on the vendor's own proprietary protocols (SNA).

In most European countries the growth of the Internet was not officially planned, and until now has had to rely on very informal management
techniques. Coordination across Europe is handled by the RIPE (from the mixed English-French acronym Réseaux IP Européens) working group, which now operates under the umbrella of RARE.

- **Summary**

In Europe today we can find a number of data networks, national or international, single- or multi-disciplinary, that provide very valuable service to their academic and research users. But if we are honest with ourselves we know that these data networks are only a pale shadow of what is available to the American academic and research community.

Unfortunately, we do not seem to be making much progress in tackling even the obvious defects. Data networking seems to be planned and operated in Europe on a country-by-country basis, and the pan-European strategy and infrastructure are missing. The authors are convinced that Europe is in the process of abandoning, almost by default, a vital segment of tomorrow's commercial and industrial base to our competitors.

### 6.2 Plans

- **A European 2 Mbps infrastructure**

It has been clear for at least a year that traffic has been growing on European networks to the point where the creation of an infrastructure of 2 Megabit per second (Mbps) international lines linking the various national and disciplinary networks would be fully justified. These lines would offer 16 times the capacity available on the 64 Kbps international lines that are in common use in Europe today, but less than 5% of the capacity presently available on the lines forming the NSFnet backbone in the USA. To date we only know of only one 2 Mbps international line that has been installed for academic and research networking in Europe, connecting Bologna and Geneva.

Several national networks already employ national lines running at 2 Mbps and above. This is the case, for example, for the Joint Academic Network (JANET) in the UK, which has installed more than twenty such lines, for SURFnet in The Netherlands, for SWITCH in Switzerland, and for the Deutsches Forschungs Netz (DFN) in Germany.

Several attempts have been made to discuss the creation of a pan-European backbone running at 2 Mbps, but little concrete progress can be reported. Besides the high cost of leasing lines at this speed, there has been a lack of consensus about the technical approach that should be adopted.

- **ENS**

As we understand it, the concept of the European Nervous System, which has been introduced into recent EC planning, is to link up the administrative and commercial computers of European Community countries, so that, for example, ordering, shipping, customs, payment and tax (VAT) can all use the same network infrastructure. If it can be achieved this
would be of enormous benefit to European commerce. We see it as an extension of ideas for Electronic Data Interchange, and in all senses complementary to higher speed academic and research networking.

- **Gigabits**

We are not aware of any presently funded project to install long-distance Gigabit per second transmission infrastructure in Europe, nor of any international collaborations set up in Europe along the lines of the five Gigabit Testbeds in the USA. The few projects already under way in Europe, such as those in Berlin and Sweden, seem to be strictly national and rather a pale shadow of the American efforts. We discuss some aspects of the European Commission's RACE programme below (under the title "Europe's conservative approach to telecoms"). In our opinion the lack of pan-European Gigabit Testbeds is extremely dangerous, since Europe will be late into an emerging technology where time-to-market will be almost everything for commercial success. It is as though we had decided in the early decades of the 20th century that we were interested in neither the automobile nor the electric light industry.

### 6.3 Barriers to progress

The reader may well wonder why the different national, international and disciplinary academic and research networks in Europe have not yet succeeded in creating a satisfactory pan-European data networking infrastructure. The answer is that many efforts have been made, but that there are many barriers to progress in Europe. These are technical, commercial, organisational and political, and we give a short introduction to some of them in the following sections. We can certainly summarise by saying that, as a community, European researchers and academics have failed to convince Europe's politicians, civil servants, industrialists and PTTs that data networking is important, and that everyone should collaborate in order to improve the state of the European infrastructure.

- **European telecoms regulations**

Even in a single market such as the USA, the regulation of telecoms is a complex matter, because the underlying technology is both sophisticated and evolving rapidly, and because enormous economic and political interests are at stake. A major feature of the decision to "divest" AT&T was the separation of the business of providing long-distance voice and data communications lines from the business of providing local services. We believe that this separation has proved to be a fundamentally sound move, which has allowed the USA to make progress in data networking in a healthy and competitive market environment.

With respect to the USA, the situation in Europe is even more confused because of the interaction of national and trans-national regulations. For European Community countries the national telecoms policies have to conform to EC policy, which is embodied in particular in the Open Network Provision (ONP) directives. These, while having many things to
say about data networking, are mainly concerned with overall questions of PTT policy and voice telephony.

Further confusion arises in Europe because we are probably at a moment of major transition in the regulatory situation. A review of the ONP provisions has been promised for 1992, and any resulting changes might have important consequences. In addition, the introduction of the Single Market in 1993 should provide a major psychological stimulus for those companies trying to provide pan-European services. The existing PTTs and other telecoms operators, such as Mercury and various American companies, are indeed exploring link-ups with the objective of covering the whole European market, but the outcome is far from clear. Overall, the complex interactions between the rapidly evolving regulatory situation and the changing commercial line-up have created uncertainty both for suppliers and customers, and are impeding progress in European data networking.

• Leased line tariffs

The high cost of leasing lines for data communication in Europe is due to a lack of competition, resulting from the regulatory situation.

Individual countries have national policies which normally give rather strong monopoly privileges to the national PTT, and, in particular, reserve to them the right to provide leased lines for data communications. In Sweden there is theoretically a competing supplier, but it is mainly involved in cellular telephony, and has had little impact on the data communications market so far. In the UK there is an effective duopoly, with British Telecom and Mercury both offering leased lines, although Mercury's geographic coverage still has some gaps.

International leased lines have to be supplied at a tariff that is simply the sum of those fixed by the (typically) monopoly suppliers in both countries.

The overall effect in Europe is to support charges that are up to roughly ten times the charge for an equivalent service in the USA. The situation is worst for long distance international leased lines between the most conservative PTTs, and best (roughly only three times American pricing) for UK national lines.

We find the continued existence of these exaggerated prices to be really rather scandalous. We cannot help noting that, under the provisions of the ONP directives, all prices charged to the user are supposed to be "cost based". We cannot understand how anyone can reasonably claim that present leased line charges in Europe are in any way "cost-based", unless that means that you take true costs and multiply by a large factor!

While the academic and research community has found ways around these high charges in some cases, by using industrial or government sponsorship, they nevertheless are acting as a huge brake on the progress of data networking in Europe. This has two major effects on European industry and commerce. First, and in our opinion this is extremely
serious, it means that all European industry and commerce is burdened by charges which are so high that they completely distort the choices that can realistically be made concerning new data network technologies. If in Europe we charge ten times too much for a new service based on data networking, then there will be very little economic incentive for most industrial and commercial users to use it. How long can we afford this sort of distortion? The second, knock-on, effect is that it results in European high-technology companies being largely absent from a major growth area.

- **No pan-European providers of leased lines**

Depending on where you draw its borders, Europe consists of some 20-30 countries, working more or less quickly towards closer economic and political integration. However, as we have discussed above, there are no pan-European providers of leased lines, since in most countries the local PTT is the sole authorised supplier. We believe that Europe urgently needs a few competing pan-European suppliers of leased line capacity, so that European industry can benefit from the enormous technical progress that is now being made in voice and data networking.

This situation largely results from the distinction made in the ONP directives between basic services, which may be reserved by a national government for a monopoly supplier, and the so-called value-added services, which are required to be open to competition. At present the provision of leased lines for data networking is regarded as a basic service. We believe that this is a fundamental mistake, and we hope that it indeed will be corrected in the review of the ONP directives that is promised for 1992.

- **Europe's conservative approach to telecoms**

Europe has a set of world-famous telecoms industry groups, including Alcatel, L.M.Ericsson and Siemens, with an enviable reputation as suppliers of voice telephone systems. Historically these groups have been used to working closely with the national PTTs, which formed the major market for their voice telephone exchanges. Both the companies and the PTTs have their own research departments which are well-respected specialists in advanced transmission techniques for voice and even data networks.

The companies and the PTTs have always had good working relationships with the various national governments (Ministries of Telecommunications), European authorities (especially Directorate-General XIII of the European Commission), and the PTT-oriented standards bodies such as the European Telecommunications Standards Institute (ETSI). This community was at the origin of X.25 and associated standards, and of the related products. It has for several years been investing heavily in the concept of an Integrated Services Digital Network (ISDN), which it hopes will become a crucial component in data communications for business and commerce, although there appear to be some serious interworking problems on the pan-European level. It is currently concentrating its
efforts for the future on the so-called Asynchronous Transfer Mode (ATM) technology, which aims to switch voice and data streams onto 155 Mbps and 622 Mbps communications lines.

The European Commission programme for Research on Advanced Communication in Europe (RACE), which is funded at a level of some 200 Mecu per year, with matching funds coming from industry, is mainly aimed at stimulating these companies. However, we believe that the overall approach of this community to data networking is rather conservative, and the situation is reminiscent in many ways of the position in America prior to the divestiture of ATT. The people concerned do not appear to us to fully appreciate the vital significance of the close relationship that has emerged between workstations, computers and data networking. As a result they do not seem to be very interested in exploring advanced applications aimed at new data networking services, and especially not on a pan-European basis.

These weaknesses seem to us to be particularly obvious in the case of the RACE application pilot projects, which we find to be poorly focussed, and which do not seem to profit enough from collaboration with the academic and research community, in strong contrast to the situation in the USA. We wish to point out that we support the strong emphasis in Europe on developing networking products for the business and commercial sector. We think that our mistake in Europe, and it is at least as much the fault of the academic and research community as of anyone else, has been the failure to exploit that community, which is good at filtering and testing new products and ideas in data networking, as a natural partner for industry.

- Protocol issues

Protocols are crucial to data networking, because they provide the definitions that give the assurance that two workstations will be able to communicate with each other. If the protocols have been defined by a computer vendor they are referred to as "proprietary", while if they are defined independently of any single vendor, and are freely available for implementation on any workstation, they are referred to as "non-proprietary" or "open". If a set of protocols is available that covers the full range of normal data networking services, we can refer to the existence of "Open Networking", which guarantees that people who have acquired their workstations from different vendors will nevertheless be able to communicate fully with each other. Network protocols are technically very complex, and they need to evolve continually in order to keep up with advances in technology, such as much higher speed connections.

About ten years ago many people, including both of the authors, held high hopes that one set of protocols, defined by the International Standards Organisation and normally referred to as the OSI (for Open Systems Interconnection) standards or protocols, would become available quickly and provide for Open Networking between different computers. For good reasons, including the general wish to be independent of any single computer vendor, and a more specific hope that a commitment to OSI
protocols would revitalise Europe's local computer industry, the European Commission's Directorate-General XIII has been a strong supporter of OSI protocols. Indeed, many of Europe's officially funded data networking initiatives have based their whole strategy on the assumption that commercial products implementing the OSI standards would become available quickly and widely, and that they would offer full functionality.

Unfortunately OSI products have taken much longer to arrive than anyone expected, and they still only offer limited functionality and performance. Furthermore, products based on another set of Open Networking protocols, the TCP/IP suite that is at the basis of the Internet, have became very widely available on computers and workstations from almost all vendors. They offer good performance and functionality at very reasonable cost, and as a result the TCP/IP suite has achieved a wide de facto acceptance in the computer industry. So while, for many reasons, OSI undoubtedly will still have an important role to play, it is no longer realistic to use it as the sole basis for the whole of Europe's data networking strategy.

Now is the time when the users need to confirm their commitment to non-proprietary Open Networking, and to plan the phase-out, as quickly as possible, of proprietary protocols. On the other hand European service providers and their backers, including the European Commission, must recognise the way in which the market has developed, and start to support all Open Networking protocols, including TCP/IP as well as OSI.

- **No fully European scientific computing companies**

To our knowledge there are no companies controlled from Europe who are presently delivering state-of-the-art scientific computers or workstations that they have designed and constructed\(^1\). To a very large extent the scientific computers and workstations used in Europe are designed in the USA and constructed in Europe by the European subsidiaries of American companies, such as IBM, Digital, Sun and Hewlett Packard.

In addition some of Europe's "national champions", such as Bull, ICL, Olivetti, and Siemens, import Japanese mainframes and supercomputers that they sell under their own label - but this seems to involve little if any European design or production capacity.

We have to mention that a report from a committee chaired by our Director-General, Professor Carlo Rubbia, at the request of the European Commission, has recently proposed various measures designed to stimulate Europe's scientific computing potential. A preparatory phase of the High Performance Computing plan, designed to exploit Europe's

\(^1\)We are, of course, aware of several European companies building computers based on the Inmos Transputer architecture, and of various European manufacturers of IBM-compatible Personal Computers. The former tend to be rather small companies, and the overall competitiveness of the Transputer architecture in the general purpose scientific computing market remains to be demonstrated. The latter are largely oriented towards commercial rather than scientific applications.
know-how in the field of parallel processing, has been included in the proposals for the Third Framework Programme (1990-1994).

The relevance of these remarks in the context of data networking is that the companies providing Europe's scientific computers are the natural partners for the European scientific community when trying to set up collaborations on advanced data networking. However the fact that many of these companies are ultimately controlled from the USA unfortunately seems to give rise to various reservations among some of the other desirable collaborators, including various PTTs and national or European authorities.

We note that, while scientific computing is a somewhat specialised field, it has been and is still at the origin of much progress in the general-purpose computing business, and that it is an industry that Europe abandons at its peril. The authors hope that Europe will try to avoid abstaining from the data networking business as well.

• **Lack of collaboration**

As has already been pointed out, there is a very healthy collaboration in the USA between the research and educational community, who know that they need advanced networking, the government, and industry, including the computer companies, the networking companies, and the common carriers. This collaboration is completely missing in most of Europe. One reason for this is surely that, as we have already pointed out, there are no fully European scientific computing companies for anyone to collaborate with, and this seems to create reservations among potential sponsors such as the European Commission. Another reason is that there are no pan-European providers of leased line capacity, and the national PTTs do not see the interest in taking part in pan-European collaborations. Finally, as also discussed above, the existing community of PTTs and their industrial partners are rather conservative and are failing to give sufficient attention to modern data networking.

• **Lack of focus**

In the USA a strong focus for networking is provided in Washington, where politicians, industry and the research and educational community have come together to act. In Europe there is no equivalent strong focus. As we have discussed there is neither a strong scientific computing industry nor a data networking industry. The PTTs all operate on a national basis and the politicians are not aware of the opportunity. The European Commission has not proved able to catalyse the creation and operation of an effective pan-European data networking infrastructure, and sometimes seems unsure about what role it should adopt. In any case, it is not just the twelve countries of the present European Community that need to be involved in European data networking. Some of the research communities realise how far behind the USA we are, but have tended to concentrate on making sure that their own disciplinary networks are improved rather than on trying to fix Europe's global problem.
6.5 *A possible way forward*

We hope that our description of the barriers to progress will have convinced the reader that the "problem" of European data networking is not a simple one. There are, therefore, no simple "solutions", but progress will only come if we can improve the understanding of the issues among Europe's politicans, industrialists, PTTs, network providers, and network users, and subsequently improve their collaboration.

After some reflection the authors offer the following suggestions as elements for building a consensus on the way to make progress.

- One key element must be to provide a stronger focus for academic and research networking at the pan-European level. Some small group of people must feel that they "own" this problem, and must be given the authority, responsibility and means for making progress.

- A second key point is that we need to give a stronger emphasis than in the past to the service needs of the academic and research users. They want high-performance and high-quality data networking services today, and they are willing to pay reasonable prices for them. These services should be based on a commitment to non-proprietary Open Networking protocols, including TCP/IP and OSI.

- The third key point is that we must build in Europe the sort of collaboration in the field of data networking that can observed in the USA, involving government, industry, the common carriers, and the academic and research community.

- While there were good historical reasons for founding EARN and RARE as separate organisations responsible for different aspects of European data networking, we feel that these reasons are no longer valid, and that they should now be asked to merge as quickly and as equitably as possible. At a stroke this merger would radically improve the European focus on data networking.

- In the coming months, RARE, or preferably the merged EARN/RARE, should be encouraged to set up its planned operating agency. In our view this should initially concentrate on providing a service for the operation of the pan-European leased lines used for all academic and research data networking, whether national or disciplinary. If this is to be successful, the goals of the operating agency must be to satisfy the needs of all users and to provide a high quality of service, so that all of the existing operators will automatically want to use this service. As mentioned above, the service must support all Open Networking protocols.

- RARE, or again preferably the merged EARN/RARE, should itself concentrate on long-term planning and policy issues, and leave day-to-day matters to the operating agency. Again, it must worry about the infrastructure needed for data networking for the whole of the European academic and research community, defined in the broadest sense. The
commitment of RARE users must be to expand the use of non-proprietary Open Networking everywhere in Europe.

- In the medium term (2-3 years) the authors would like to see RARE evolve into a European Treaty Organisation with the mission to plan and oversee the operation of Europe's data networking infrastructure. We refer to this as the European Data Network Agency (EDNA). Membership of such an agency would be open to all European countries, whether from the EC, EFTA, central and eastern Europe, or elsewhere. The Agency would provide a good forum for future planning and the fact that it was a treaty organisation should ensure that it receives enough high-level political and industrial attention. It should keep its own staff numbers at a low level, and aim to use commercial services as soon as the requirements for those services are clearly understood, but not before.

6.6 Europe's Missing Infrastructure

Although it does not have very much to say about data networking, we find ourselves largely in agreement with the arguments presented in the document "Europe's Missing Infrastructure", from the European Round Table of Industrialists. That document concentrates on road, rail, and air transport networks, pointing out how serious the effects of the missing infrastructure can be for the creation of the single market. It also highlights the effects of the missing infrastructure in Central and Eastern Europe.

7. What happens if we do nothing?

Despite the complex and difficult situation in which we find ourselves, and despite the really frustrating lack of progress over the past few years towards creating a viable pan-European infrastructure for data networking, all is not lost. Provided we clearly identify the problems that are facing us, and decide how they should be tackled, Europe certainly has the skills, the industrial strength, and, we hope, also the will, to make the necessary breakthroughs.

However, if we do nothing the authors are convinced that European data networking will remain underdeveloped in the short term, and will then quickly be colonised by companies based in the USA who have understood the developments needed in this fascinating market, which is so full of opportunity for progress and profit. Put bluntly we will have abandoned European data networking to some combination of American computing and networking companies.

Note that we feel that the undoubted industrial strength of some of Europe's suppliers of voice networking services, such as Siemens and Alcatel, will not be sufficient to stand up to the American wave, unless they move very quickly to emphasise data networking in the context of the whole of Europe. But, as we have argued, the lack of European common carriers and scientific computing suppliers is likely to make that difficult.
8. Conclusion

We are convinced that data networking is an emerging industry where Europe is almost absent. We believe that industrialists and politicians must be given this vision, and then encouraged to take appropriate action. We need to obtain a commitment from all influential people and bodies for an urgent programme to build a solid pan-European infrastructure for data networking. We believe that, over a period of a few years, the European academic and research community should evolve the existing bodies that are responsible for various aspects of data networking into a small European Treaty Organisation, which would become the main vehicle for future action.
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