

The Case for

National Research and Education Networks (NRENs)

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« *networking the networkers* »

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Introduction

There is a general perception in the research and education community that National Research and Education Networks (NRENs) are special, providing services and support unavailable elsewhere. From time to time counter views have been voiced, generally from outside the community.

There is no single formula that can be used to accurately model all NRENs, as their precise constitution and funding are influenced by local conditions. However, it is clear that the majority of European NRENs have common characteristics; namely that they are not-for-profit organisations providing advanced services to a well bounded community.

This paper provides an assessment of the current role of European NRENs and explores the case for their continuation.

The European NREN model

In many respects Europe has become a world leader in research and education networking. One of the enabling factors has been the way in which Europe has organised itself. The organisational model of a single NREN per country with co-ordination and collaboration at the continental level has been the key to success. Consequently the European model is being copied in other world regions.

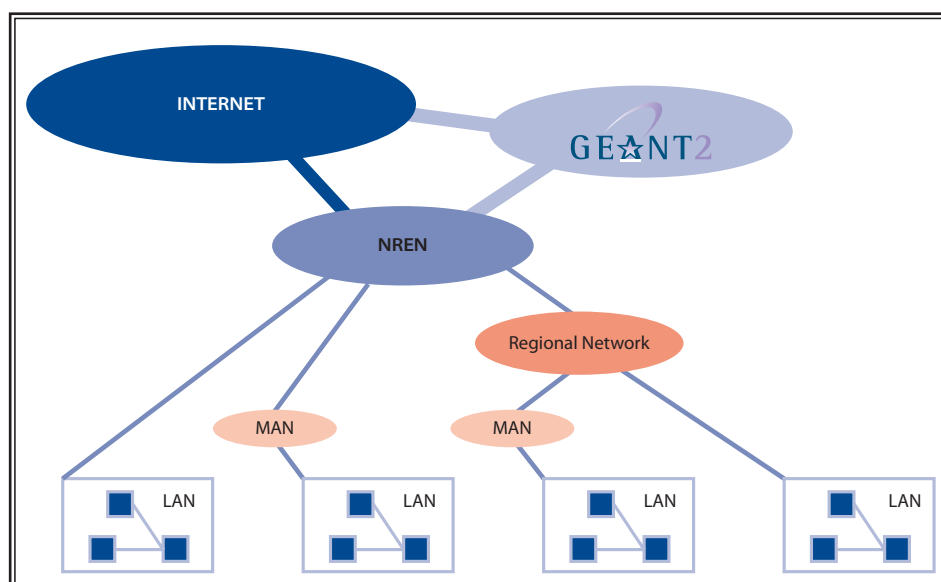


Figure 1: Structure of research and education networks in Europe¹

¹ Innovation, Integration and Deployment (EARNEST Summary Report), 2008

URL: <http://www.terena.org/activities/earnest/docs/20080429-final-report.pdf>

Local Area Networks (LANs) are closest to researchers, teachers and students and are the responsibility of the local research institute, university, school etc. The personnel who provide network connectivity and services at the campus level play a crucial role as the first link in the networking chain. Local technicians are in a good position to understand the needs and aspirations of the users and help them to develop and use the services effectively.

At the national level is the network that interconnects the local networks of the research institutes and institutions of higher education in each country. This level is the responsibility of the National Research and Education Networking organisation (the NREN) of that country. In some countries campus networks are not connected directly to the NREN but via Metropolitan Area Networks (MANs) or regional networks.

At the international level, connectivity between the European NRENs is provided by the GÉANT network, managed by DANTE on behalf of the NRENs. Connectivity to research and education networks on other continents is also provided by DANTE, but some NRENs additionally have their own links to key destinations. The concept of using Cross-Border Fibres, commissioned or operated by the NRENs themselves, is also becoming more prevalent. Connectivity to the commercial Internet takes place both at the NREN level and, to a limited extent, at the GÉANT level.

This model has led to the development of a community dedicated to cooperating and working together for the common good of research and education. Within the community are many acknowledged world experts in the field of networking, which, coupled with the collaborative spirit, is a major driver behind the innovation that NRENs deliver.

There is evidence^{2,3}, that the availability of cost effective and cutting edge NREN network services enables and encourages technological spillover into the commercial sector, which ultimately benefits society as a whole. Conversely, the absence of such facilities hampers such development and can exclude countries from achieving advances that could help their economic development.

2 *Innovation, Integration and Deployment (EARNEST Summary Report), 2008*

URL: <http://www.terena.org/activities/earnest/docs/20080429-final-report.pdf>

3 *REANNZ Value Proposition "Underpinning New Zealand's future economy", REANNZ, June 2008*

URL: <http://www.karen.net.nz/assets/Uploads/Publications/REANNZ-Value-Proposition.pdf>

NREN characteristics and services

It is clear from studies such as SERENATE⁴ and EARNEST^{5,6} that users in the research and education sector are making increasing demands for advanced network services in order to compete on the global stage. These advanced services are often developed and provided by the NRENs, as they are not available in a pervasive way from commercial Internet Service Providers (ISPs).

It should be noted that, some years after they enter common use in NRENs, NREN pre-commercial developments frequently find their way into commercial ISP networks, benefiting public Internet users as a whole.

It is enlightening to explore some specific activities and benefits that can be attributed to the NRENs:

- » The NREN community has pioneered the development and use of hybrid networking technology, in which general IP traffic and high bandwidth (10 and 40 Gbps) lightpaths may be concurrently supported on a single infrastructure whilst not interfering with one another. Ultimately this will lead to user-controlled, on-demand dynamic bandwidth being available to those who need it. This will particularly benefit intensive network users such as the e-Science community.
- » Pan-European Performance Enhancement and Response Teams (PERTs) are being put in place. The PERTs will investigate and rectify problems in the pan-European infrastructure to ensure an optimal end-to-end application performance for the end users. It is unlikely that such end-to-end support will be available across commercial ISP networks in the near future.
- » A confederation of trusted federations is being built to provide pan-European authentication and authorisation between community users and resources. This development will support the creation of dynamic virtual organisations that undertake collaboration between geographically distributed teams as and when needed. The authentication and authorisation infrastructures will be federated at the European level whilst retaining the local management and fine level of granularity that the community requires.
- » The NRENs are part of the research and education community and hence close to the constituency that they serve. They are generally independent of specific suppliers and solutions and are trusted by the community to deliver good high quality services at an economic price.

⁴ SERENATE Final Report, 2003

URL: <http://www.terena.org/publications/files/SERENATE-FINAL.pdf>

⁵ Innovation, Integration and Deployment (EARNEST Summary Report), 2008

URL: <http://www.terena.org/activities/earnest/docs/20080429-final-report.pdf>

⁶ Report on Researchers' Requirements (EARNEST Sub-Study), 2007

URL: <http://www.terena.org/activities/earnest/docs/20080204-researchers-requirements.pdf>

- » NRENs are in a position to undertake applied research along with members of its own constituency in a way that commercial concerns would find difficult. This allows the development of national and international test beds and pilot services, many of which result in new production services. Advanced NRENs stimulate innovation in the research and education community and bring forward technological advances. These developments usually find their way to commercial ISPs and benefit the public at large some time later.
- » Almost all national telecommunications infrastructures were originally monopolistic providers of infrastructure. Many studies, including that conducted as part of SERENATE, reveal the high pricing structure that follows from such a situation. The community has worked with the European Commission, national governments and alternative suppliers to counter the damaging effects of such market conditions. These actions have had beneficial effects for the market as a whole. Whilst not completely solving the problem, these activities have contributed to the lowering of barriers in the digital divide. The principle of solidarity amongst European NREN community members has brought about the inclusion of disadvantaged regions whilst maintaining a fair balance of cost sharing in ventures such as GÉANT.
- » NRENs have been able to bring the benefits of collective buying power to universities by procuring networks and services on a national basis. This provides savings for the community and the participating countries. The same is true on an international basis, where DANTE has been able to procure international connectivity on behalf of all European NRENs.
- » Individual institutions or indeed countries may find it difficult to become a serious player on the international stage. Being affiliated to the NREN community and representing it on the international level gives credibility and enhances the ability to actively participate
- » The independence of NRENs is a valuable asset when advising on the development of national policy on education, research and IT. NRENs occupy a position of trust in this respect and can be called upon to provide guidance uninfluenced by the pressures and demands of commercial business. Many NRENs are already recognised as a pool of independent expertise that is an asset to its country.

Why is it reasonable to provide explicit justification for the NRENS?

From time to time there have been discussions within the NREN community about the 'special position' that NRENS occupy. Whilst for the reasons stated earlier in this paper it might seem clear to many that NRENS are a force for public good, it would be complacent for any organisation not to consider its *raison d'être* and to be in a position to justify its existence. Furthermore, NRENS are generally consumers of public money (directly or indirectly), so it is essential that they are open and accountable for its expenditure, demonstrating the justification and value of such funding.

If NRENS can only provide the same services as are readily available on the commercial market, or if NRENS are more expensive than the commercial market, then there could be a case for them to disappear. This is currently not the case. NRENS provide innovation and end-to-end services not generally available in the commercial market and are still the source of much Internet development. In addition, NRENS bring the added synergy of a collaborative pan-European community working together for the common good.

Despite the above, it is possible that at some time in the future the position and value of NRENS may be questioned. Scrutiny could come from several quarters and might raise the following potential issues:

- » Why is there a need for NRENS when there is a competitive ISP market?
- » Why should NRENS receive funding from public sources?
- » Doesn't the existence of NRENS distort the Internet market through unfair competition?
- » What should be the regulatory status of an NREN?
- » To what extent should the European Data Retention Directive apply to NRENS?

Addressing the questions and issues

» **What is the need for NRENs when commercial ISPs exist?**

NRENs came into being at a time when networked data communications were not generally provided by the commercial sector. The NRENs and research users' community became adept at developing the necessary communication protocols and finding innovative ways of using the network to support education and research. This situation still persists. Although cutting edge industrial research leads to new high-speed and advanced components, much of present day Internet innovation is still undertaken within the education and research community. Commercial ISPs do not have sufficient motivation to reach the level of innovation needed by the education and research community. Whilst it may be arguable that some advanced ISPs may be able to offer some NREN core services at a price that is lower than the NREN's, careful account must be taken of the true costs of relying on externally provided services which may not provide the full range of facilities that the community requires. In addition, uptake of such commercial services would result in the dilution of the community-led innovation that has been seen in the past.

As an example, some commercial organisations (for instance Google) offer "free services", but institutional integration and management have a significant cost⁷. NRENs are still able to provide services that are generally better or more economic than using 'free' external services.

It is also clear from the EARNEST study that members of the research and education community value the advanced services that the NRENs provide and indeed are willing to pay for them. A practical example of this is the way in which the majority of NRENs use over-provisioning as the most effective way of providing their users with good Quality of Service, a feature that encourages the innovation of advanced value-added applications.

» **Why is there a need for central / government funding of NRENs?**

The majority of European NRENs receive some funding support from national government. Similarly the GÉANT network that connects European NRENs internationally has been receiving a financial contribution from the European Commission.

The SERENATE study⁸ recommended that: "National governments should be aware that research and education networking in their country, and in particular their National Research and Education Network organisation (NREN), is an asset for economic growth and prosperity. It is a source of innovation and provides

⁷ *The Launch of Google™ Apps at USC: Determinants, Decisions, and Deterrents*

URL: www.internet2.edu/presentations/fall08/20081015-googleapps-bellina.pdf

⁸ *Networks for Knowledge and Innovation, A Strategic Study of European Research and Education Networking, SERENATE Summary Report, TERENA, December 2003*

URL: www.terena.org/publications/files/SERENATE-FINAL.pdf

fast and widespread technology transfer to society and industry. Promoting such technology transfer should be an explicit goal of NRENs". It therefore seems quite reasonable that governments, both at the national and European level, make some contribution to the continued development of such an asset that benefits society as a whole.

It also seems reasonable that network users should be prepared to make a financial contribution for the production services they use.

As a result of their short-term funding constraints, user institutions find it difficult to provide funding for innovation or the large periodic investments needed for step improvements to the network when there is a change in underlying technology.

Application of the principal / agent theory and transaction costs, suggests that a hybrid funding model may be beneficial⁹. Users pay a fair contribution to the cost of production services, whilst government takes the longer-term view funding innovation and upgrades.

Most European NRENs follow a hybrid model of funding to some extent.

» **Relationship with the ISP market**

Whilst it varies between countries, the NRENs generally operate as a network for a closed group of users who have advanced requirements to support their research and education users. These requirements are not generally satisfied by commercial offerings from ISPs. The NRENs do not compete with commercial ISPs, but offer a different level of service in parallel with them.

It would be beneficial for both NRENs and ISPs to develop collaborative links and work together on developments for the future. Indeed the SERENATE¹⁰ study made a recommendation in this respect: "NRENs and industry should ensure that collaboration between research teams in industry and teams in universities and publicly funded research centres can be supported effectively".

In addition the NREN often operates as the centre of a research and education consortium, acting on behalf of its constituency to organise joint purchases of services. This does not bring any distortion of the market, but is merely good practice on behalf of the community.

⁹ REANNZ Today, *An analysis of advanced networking in New Zealand*, REANNZ, June 2008

¹⁰ *Networks for Knowledge and Innovation, A Strategic Study of European Research and Education Networking*, SERENATE Summary Report, TERENA, December 2003

» **Regulatory position of NRENs**

NRENs offer their services to the well bounded and closed community of education and research users. Sometimes equally well bounded and related groups are added to the core education and research community if there is an identifiable benefit in doing so. The community using the NREN network is thus a well bounded, closed user-group. NRENs are not in the business of providing public services and hence should not be regarded as public network operators.

It makes good sense for NRENs to adopt best industry practice in the operation of their networks, despite being a non-public network operator.

There are arguments that making NRENs register as public network providers, with the administrative requirements it imposes, will change the very nature of NRENs and detract from their innovative and pioneering capabilities.

» **Regulatory requirements for data collection and retention**

Requirements for data collection and retention to comply with the European Data Retention Directive¹¹ might constrain NRENs to build networks that are less than optimal for their primary purpose.

Most NRENs now have backbones in the form of multiple rings with duplicate regional and international connections in order to provide the reliability and traffic management ability needed for demanding real-time applications. These architectures provide many different routes for traffic between most points on and off the network. Any requirement to provide complete accounting for, or filtering of, traffic on the backbone would therefore be likely to require the re-introduction of single points of failure or congestion where such filtering or accounting could take place.

In addition, the costs of putting into place facilities to meet the requirements of the Directive are not yet known. Estimates have been made in several papers including an extensive technical evaluation undertaken by the Faculty of Computer Science at the University of Vienna, Austria¹². The expectation is that the administrative and financial burden would be high and detrimental to education and research.

¹¹ Directive 2006/24/EC of The European Parliament and of The Council

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:105:0054:0063:EN:PDF>

¹² The EU Data Retention Directive 2006/24/EC from a Technical Perspective

G. Stampfel, W. Gansterer, M. Ilger, K. Stark, Department of Distributed and Multimedia Systems
Faculty of Computer Science, University of Vienna, Austria, October 2007

Conclusions

It can be demonstrated that the NRENs do indeed occupy a special position outside the commercial Internet market. They operate as not-for-profit organisations serving a closed user group and consequently there is a case for them to be designated as non-public networks.

NRENs are still the source of much Internet innovation, much of which will spill-over into the commercial Internet for the benefit of society in general.

National governments should regard their NRENs as a national asset to be fostered and supported by central contributions to a hybrid funding model. In this way they will benefit industry and ultimately their citizens generally.

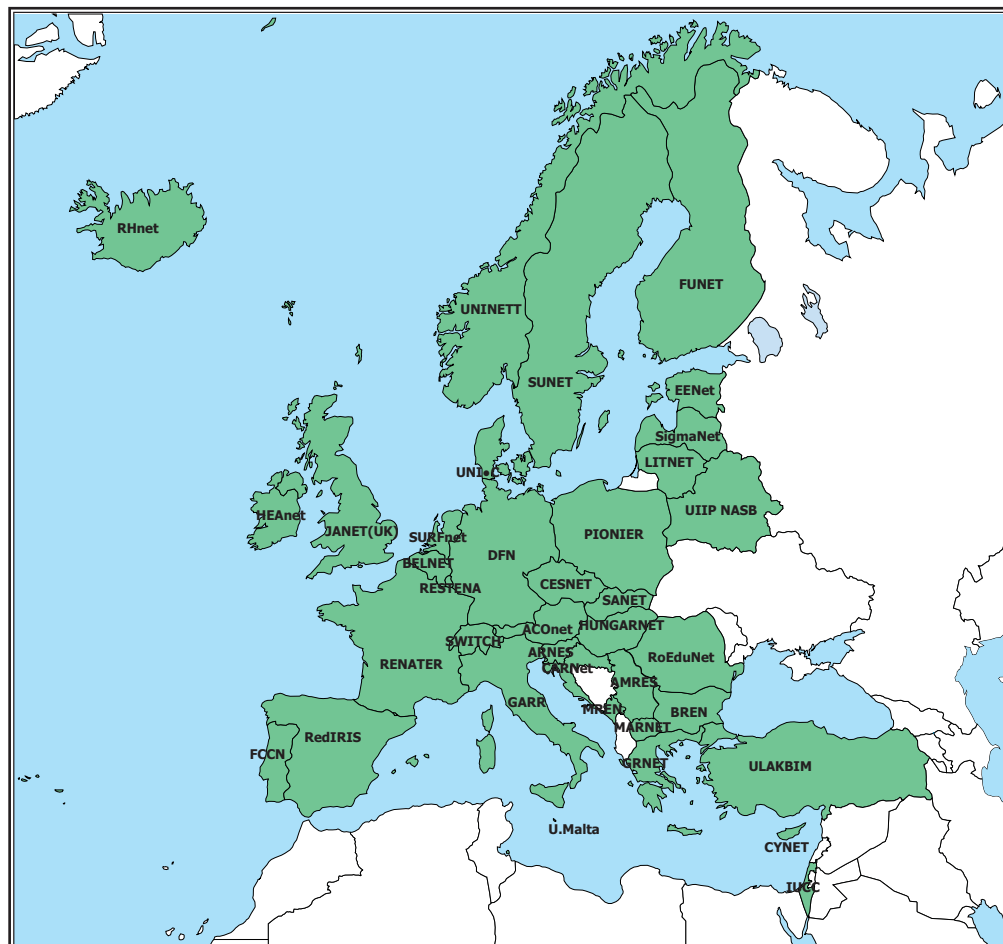


Figure 2: European NREN members of TERENA

Epilogue

There has long been debate regarding the use of public funds to drive innovation, with particularly important contributions from Francis Bacon¹³ (1561–1626) and Adam Smith¹⁴ (1723-1790). There are philosophical arguments for the use of public funds to support science and innovation and there are equally compelling arguments against such use of public funds. More recently, the Organisation for Economic Co-operation and Development undertook an analysis that is published in *The Sources of Economic Growth in OECD Countries*¹⁵ which seems to disprove Smith's assertions. No matter which side of the argument eventually proves to be accurate, a common theme emerges. Innovation and hence progress is best driven when individuals and organisations take ownership of the problems to be solved.

It is commonly accepted that we now live in a knowledge society in which many people value the pursuit of intellectual achievement as equal to the pursuit of wealth. When we talk of 'ownership', we should therefore consider intellectual attainment as being equally as valuable as the creation of monetary wealth.

An NREN is almost always a not-for-profit organisation with a proportion of staff being part of, or very closely related to, the research and education community. Many NREN staff are proud to be part of the community they serve and can be highly motivated by the positive way in which their work can provide benefits that support academic advances. There is a level of ownership found in NRENs that is a major driver in their success. It is unlikely that such ownership could ever exist if the development of research and education networks were left to commercially motivated organisations.

13 *The Advancement of Learning*, Francis Bacon, 1605

URL: <http://etext.library.adelaide.edu.au/b/bacon/francis/b12a/complete.html>

14 *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam Smith, 1776

URL: <http://www.econlib.org/LIBRARY/Smith/smWN.html>

15 *The Sources of Economic Growth in OECD Countries*, OECD, 2003

URL http://www.oecd.org/dac/ictcd/docs/otherdocs/OtherOECD_eco_growth.pdf

Appendix - A Brief History of NRENs

In the 1970s, research and education networking existed only as small ad hoc arrangements to meet local needs. These were the times of non-inter-working proprietary operating systems and communications protocols.

Around the end of the 1970s, the activities in some countries started to gel into more organised projects exploring how to integrate the existing ad hoc facilities into a common set of standard ways of working that could be used on a national or even international basis. The underlying technology that supported these networks was copper wire, owned and operated by monopoly suppliers willing to lease circuits. The cost of leasing a circuit seemed directly linked to the amount of revenue that the line might generate if it were used for telephone calls, and consequently was very expensive.

Whilst big financial institutions with a very limited set of applications could commission specialist software to meet their needs, providing the means to encourage innovation across disparate research and education sectors around Europe was an entirely different matter. It was clear that the commercial providers were very good at delivering telephone services but unprepared to deliver advanced data networking services.

Many governments recognised the importance of providing their academic communities with good data network services and were willing to provide some funding towards the development. This led to the initiation of projects and teams that would work on integrating the disparate components in a way that would bring about pervasive inter-working between systems. By 1985, these activities gave birth to eight dedicated organisations in Europe and by 1990 the number had risen to fifteen.

Serious computing power was only available in specialist centres. The computers of this period were large machines, housed behind glass and guarded by operators in an air-conditioned and clean environment. Access to the centres was either by visiting in person or using some dial-up link with modems and terminal adapters.

Whilst researchers and other users wanted remote access to these computers, engineers and scientists also recognised the benefits of being able to transfer data between machines. Networking technology was relatively slow and simple. If one was sufficiently motivated, with the help of some programming skills, simple components and a soldering iron, one could enable computers in the lab to exchange data. Bearing in mind that off the shelf modems operated at 300 baud (0.3kbps), file transfer over a telephone line was an excruciatingly slow business.

Several pioneering European data networks that developed in the research and education community were based on X.25, supporting a raft of applications including those implemented to the coloured book standards¹⁶. In the US they were

¹⁶ Wikipedia has an article on the coloured books - URL: http://en.wikipedia.org/wiki/Coloured_Book_protocols

based on Network Control Program (NCP) and Unix-to-Unix Copy (UUCP).

What was common on both sides of the Atlantic was the innovative and pioneering spirit in the research and education community, which led to rapid advances that would ultimately find their way to commercial and public networks.

In the UK, the JANET network initially operated at speeds of 9.6 kbps. By the early 1990s it had reached 8 Mbps, which was the fastest X.25 network in the world at the time. Along with the underlying transport systems, application protocols for terminal access, file transfer and electronic mail were supported to provide a range of useful services to the users. What had developed out of necessity provided the foundations for what has become an effective and enduring model for serving the demanding requirements of the research and education community.

The combination of knowledgeable users having both skills and ambitions was the key to making working solutions in a world where the telecommunications monopolies could see little economic reason for developing such services.

Whilst it takes advanced laboratories and huge resources to develop the current range of networking components, such as 40 Gbps optical interfaces, optical switches and massive routers, the NRENs are still at the leading edge of integrating these devices into pervasive end-to-end services that are capable of meeting the needs of education and researcher users.



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