Report on
Requirements of Users in Schools, the Healthcare Sector and the Arts, Humanities and Social Sciences

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1. Executive Summary

The EARNEST foresight study has looked at the expected development of research and education networking in Europe over the next 5-10 years. The study was carried out between March 2006 and November 2007. EARNEST was funded by the European Union through the GN2 project, which also provides the funding for the current generation of the pan-European research and education backbone network, GÉANT2.

The aim of EARNEST was to provide input for initiatives that could help to keep the evolution of European research networking at the forefront of worldwide developments and enhance the competitiveness of the European Research Area. EARNEST has prepared the ground for the planning of the development of research and education networking infrastructure and services after the completion of the GN2 project, at the local, national, European and intercontinental level.

EARNEST can be seen as the successor of the very successful study that was carried out in the SERENATE project in the period from May 2002 until December 2003. The results of the SERENATE study, and in particular the recommendations in its Summary Report, have been very influential on the planning and development of research and education networking in Europe in subsequent years.

After an initial preparatory phase, the EARNEST work has focused on seven study areas: researchers' requirements, technical issues, campus issues, economic issues, geographic issues, organisation and governance issues, and requirements of users in schools, the healthcare sector and the arts, humanities and social sciences. Reports have been published on the results of each of these sub-studies, as well as an additional report on regulatory issues. The EARNEST study is rounded off by a Summary Report that contains recommendations for the relevant stakeholders.

The current report provides the results of the EARNEST study of the requirements of 'other' users, i.e., (potential) users of the infrastructure and services offered by research and education networks who are outside the traditional user community of researchers, teachers and students in higher education. At the start of the Sixth Framework Programme for Research and Technological Development, the European Commission was already promoting greater 'inclusiveness' of the research networking infrastructure, asking that the demands of various parties in the field, such as schools, educational networks, libraries etc. be taken into account.

In recent years, research networking organisations in different countries have paid more attention to these 'other' user groups and increasingly they are providing services to them. However, which user communities are served and the extent of the services provided to them varies significantly from country to country.

The EARNEST study of the requirements of 'other' users has focused on three user communities that were identified as the most interesting ones in the current stage of the development of research and education networking in Europe: schools, the healthcare sector, and the arts, humanities and social sciences.

Therefore, the current report is largely a compilation of three study reports. Requirements of users in schools were investigated by Andrew Perry (Department for Children, Schools and Families, United Kingdom), with input from a TERENA-organised EARNEST workshop on schools. A report on networking in the healthcare sector was written by Christina Wanscher (MedCom, Denmark) with Henrik Søndergaard and Martin Bech (UNI•C). Networking requirements in the arts, humanities and social sciences were studied by Sabine Jaume-Rajaonia (RENATER) and Cătălin Meiroşu (TERENA Secretariat). Some general highlights and recommendations are presented in the introductory chapters.

2. Introduction

One of the seven study areas of the EARNEST foresight study has looked into the requirements of 'other' users. Increasingly, research and education networks (at the national, regional and local level) connect not only researchers, teachers and students in research institutes, universities and other institutions of higher education, but also other kinds of users (in the public sector). This greater 'inclusiveness' of research and education network infrastructure and services in Europe is a development of strategic value, both for the research and education networking community and for the 'other' users themselves.

In the earlier SERENATE study (2002-2003), a number of case studies[1] were produced to highlight these new types of users and their requirements, as well as the consequences of the greater inclusiveness for the organisation and operations of (national) research and education networks. Examples were schools at all levels of the education system, students at home, public libraries and museums, and government institutions.

Four years later, the situation has undergone some changes. It is not the case that all types of users referred to above are now served by (all) national research and education networking organisations, but there has definitely been a trend towards greater inclusiveness. Some new types of user groups have surfaced in the past four years. Some new types of requirements have also appeared.

Therefore, EARNEST has revisited this area. In doing so, attention has focused on three user communities:

- schools;
- the healthcare sector;
- the arts, humanities and social sciences.

It is important to note that it is now quite well understood how to connect schools and therefore EARNEST focused on the actual use of networks by schools. The arts, humanities and social sciences are also a community where networking plays an important role. Similarly, EARNEST has studied the network use of this community and the services that are being requested. By contrast, the healthcare sector is a very new area for the research networking community. This report contains more detailed information about this sector and its needs; that information will be useful for those research and education networking organisations that wish to establish a plan or strategy to work with this community of (potential) users.

2.1 Schools

In recent years, National Research and Education Networking organisations (NRENs)[2] all over Europe have increasingly brought Internet connectivity to schools. The different technical and organisational options for connecting schools and their pros and cons are now well understood. The exchange of information between NRENs in the past 3-4 years has enabled NRENs to learn from each other and find the best solution for their own countries.

1. *Sabine Jaume-Rajaonia et al., Report on examples of extension of research networks to education and other user communities. See www.terena.org/publications/files/SERENATE-D15.pdf.*

2. *In this report, the acronym "NRENs" is used to denote National Research and Education Networking organisations as well as the national networks provided by them.*

It is now time for research networking organisations to go one step further and to look systematically at the services that can be provided to schools by NRENs (and others) and at the actual use that schools make of the Internet and the resources available via the Internet for the teaching and learning process.

This is the subject of a study report written by Andrew Perry (Department for Children, Schools and Families, United Kingdom).

This study provides qualitative information based on interviews and feedback from practitioners about the use of network connections. For those interested in figures and comparisons between countries, the study provides references to interesting quantitative studies. Indeed, one surprising remark in the study is that virtually every school in Europe has access to the Internet: in most countries the rate is 100% or almost 100%. Here we must note carefully that a school having access to the Internet does not mean necessarily that the Internet connectivity is used for teaching and learning. For example, it may even be that there is one PC connected in a school's administration. The study explains that there are differences in bandwidth available for schools across Europe.

The report on schools concludes that the use of network connectivity in the classroom is not yet ubiquitous.

As part of the EARNEST study of organisation and governance issues, an extensive questionnaire was sent to NRENs, which included questions related to connecting schools. Some results from that survey will be presented in Chapter 3 to complement the findings of Andrew Perry's study.

2.2 The arts, humanities and social sciences

The Arts, Humanities and Social Sciences (AHSS) communities are not totally new users of research and education networks. Indeed, many people active in the social sciences and the humanities are employed by universities and research institutes, which are the original core target group of NRENs, and this also holds true in part for the arts. However, new applications are appearing in the humanities and social sciences that make particular demands on research networks and the services provided by them. In the arts - for example, in the performing arts - innovative and very demanding network applications are also being developed.

These developments are described in a study report written by Sabine Jaume-Rajaonia (RENATER) and Cătălin Meiroşu (TERENA Secretariat).

Their report contains a large number of examples of novel network applications and looks at the services provided by NRENs to satisfy the needs of this user community.

2.3 The healthcare sector

Although NRENs usually connect university hospitals and in some European countries a small number of other hospitals as well, in general, NRENs do not serve the healthcare sector. There are a number of reasons for that. However, because in many countries the need for a high-level information and communication infrastructure is now appearing high on the agenda of the healthcare sector, there is an opportunity for that sector to learn from the experience of the research networking community, while for an NREN the healthcare sector could be a prime candidate for a large extension of its 'inclusiveness'.

These issues are described in a study report by Christina Wanscher (MedCom), Henrik Søndergaard (UNI•C) and Martin Bech (UNI•C). Their report describes the complex context as well as recent initiatives in a large number of European countries to establish a network and information infrastructure for the national healthcare sector. The report focuses on national healthcare networks, and not on diverse projects (like, for example, research and healthcare projects related to breast cancer) that may include some hospitals in some countries.

The authors also discuss the barriers that NRENs face to deliver their services to the healthcare sector and they make recommendations on how to overcome these obstacles should an NREN wish to serve this community.

3. Highlights

In many cases it is not correct to describe schools, the healthcare sector, the arts, humanities and social sciences, and other, similar communities as *new* users of research and education networks. However, they are *different* user communities, in that they have different working methods, constraints and needs than the research and higher-education communities that have been the dominant users of research and education networks for many years. For this reason, they need to be treated differently by NRENs. These users deserve special attention from NRENs and in many cases, tailor-made services.

3.1 Specific users

Schools, the healthcare sector and the arts, humanities and social sciences can also be described as large users, albeit in different ways.

Some of the novel forms of use of networks in the arts, humanities and social sciences require high bandwidth and guaranteed high levels of service.

For schools, the bandwidth required per institution and per end-user is not very high, unless videoconferencing is going to be more widely deployed than it currently is. However, because the number of schools and the number of teachers and pupils are very high, they form a large community that needs special measures from research network organisations to cope with their requirements. The aggregate bandwidth needed to serve all of the schools in a country may not be high compared to that needed for certain demanding research applications, but the sheer number of institutions to be served puts high demands on NRENs.

If NRENs are able to extend their services to the healthcare sector, then that sector will definitely become a large user, in terms of the number of institutions and their locations, in terms of the network capacity and services that they will require, and in terms of the amount of data to be transferred.

3.2 Network organisation and the choice for the NREN

There are number of different scenarios to bring connectivity to schools in a country:
- connection via a dedicated schools network;
- connection purchased from a commercial Internet Service Provider;
- connections provided by a mix of telecommunications operators, commercial Internet Service Providers and the NREN;
- connection via a regional or metropolitan-area network;
- direct connection via the NREN.

The feasibility of the last option may be different in different countries, because of different connection policies: some NRENs may connect (certain categories of) schools while others may not. Regarding the second option, it should be noted that the study highlights that the choice for a commercial Internet Service Provider is often the result of a choice between low prices (the commercial Internet Service Provider) and high quality with a broader package of services (the NREN). The outcome will be different when the NREN can offer connectivity to schools free-of-charge. Finally, the study reports that in small countries the NREN often connects schools, because it has few universities to serve and extending its user community is important for achieving critical mass.

Many users in the arts, humanities and social-sciences communities use the connection provided by their university, and therefore they have not explicitly opted for the NREN. However, it might be valuable to note that in their contacts with users, the authors of the report on the AHSS were told that the community federation and high-speed networks were important factors

In the health sector it is important to note that health data networks are mainly regional, although a few are national. The situation in different countries and regions is very heterogeneous. Just as in the area of schools, politics has a strong influence on decisions in the healthcare sector.

3.3 Issues of reliability and quality of service

As stated in the study report, schools do not necessarily need high bandwidth, but they do need a reliable and secure infrastructure. This is also an obvious requirement for the arts, humanities and social sciences.

A very surprising finding of the study on healthcare is that one of the main obstacles for NRENs to offer their services successfully to the health sector is perceived limitations of NRENs to offer guaranteed levels of service. Obviously there is a need for stakeholders in the health sector to understand better what NRENs can provide in terms of infrastructure and quality of service, as compared to other connectivity and service providers. If an NREN is able to offer a service level agreement, then that may reduce the perceived limitations of the NREN in offering guaranteed levels of service.

3.4 Understanding user needs - knowing the NREN

The study on schools found that there is currently a perceived gap in understanding between the technicians, i.e., the people in the NRENs, and the practitioners. If what is provided by the technicians is not what the schools want, then the schools will not use it. Of course, this implies that the situation will be even worse if the school has chosen to obtain connectivity via a commercial Internet Service Provider, unless such providers put dedicated teams in place to support the practitioners in schools, which is unlikely.

Schools have expressed their needs in terms of reliable infrastructure and interoperability, but also in terms of training in the use of ICT and in terms of technical support.

As part of the EARNEST study of organisation and governance issues, NRENs were asked what services (present or planned) they offer to schools. The responses from fifteen NRENs mostly mentioned IP address management, helpdesk services, router configuration, Web hosting, videoconferencing, VoIP and QoS. Other services listed by NRENs in reply to this question included LDAP, eLearning, email, DNS and VPN - but not training.

This need for training is also expressed in the AHSS community.

The report on schools expands on the fact that using the Internet is in some countries part of the curriculum now, and that integration of ICT in the pedagogical frameworks is complicated. Indeed, the report explains that in order to achieve that integration teachers need to use their subject expertise to select appropriate ICT resources, which will help them meet the specific learning objectives. In addition, the report states that many teachers require training in the use of technology; otherwise it will just remain in the classroom unused. In the arts, the network brings new trends leading to pedagogical changes in the student curriculum.

3.5 Security and authentication

Another characteristic that the three sectors in this report have in common is the requirement for high-quality security and the need for a high-quality authentication and authorisation infrastructure. Again, there are different aspects to this for the three sectors.

For example, protection against harmful content is a major issue for schools. In some cases NRENs even provide content filtering, and at the EARNEST workshop on schools held in Paris in February 2007, practitioners expressed different opinions about this issue. As part of the EARNEST study of organisation and governance issues, NRENs were asked what network security measures they were offering (or were planning to offer) to schools. The responses from fourteen NRENs are summarised in Figure 3.1.

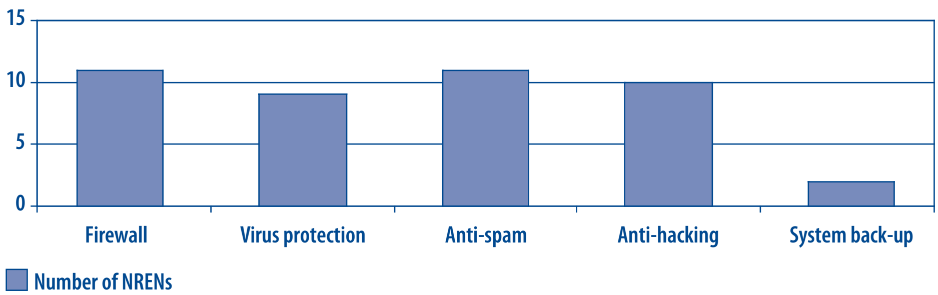

Figure 3.1: Network security measures provided by NRENs to schools

In the arts, humanities and social sciences, issues of copyright and intellectual property rights may play an important role.

In the healthcare sector, the integrity and confidentiality of patient data needs to be guaranteed to the highest possible standard. It is important to note that this sector does not perceive that the NRENs are able to adequately protect the confidentiality and integrity of sensitive personal data.

4. Some general conclusions and recommendations

Schools, the healthcare sector and the arts, humanities and social sciences are three examples of (potential) user communities of research and education networks that are 'different'. They differ from the research and higher-education communities that have been the dominant users of research and education networks for many years, because they have different working methods, constraints and needs. They are also potentially large users of research and education networks, albeit in different ways. For schools, the required bandwidth per end-user or per institution may not be very high, but the very large number of institutions and end-users puts demands on the organisation of, and service provision by, research networking organisations that are different from what many of them are used to. Novel applications in the arts, humanities and social sciences require high bandwidth and guaranteed levels of service. The healthcare sector is potentially a large user of NRENs, both in terms of data volumes and in number of institutions and end-users. Moreover, this sector has very special security requirements.

Because the three sectors are so different from the traditional users of research and education networks, they need to be treated differently from other users if an NREN decides to extend its 'inclusiveness' by offering connectivity and services to one or more of these sectors. They deserve special attention from the NREN and a tailor-made package of services.

Whether or not NRENs offer their services to these sectors is a matter of policy. Such a policy decision is dependent on available human, network and other resources, on funding and on restrictions that may be imposed by governments or other authorities. In many cases, such decisions are not made by the NREN and the sector concerned, but by the government or in the national political debate.

Nevertheless, research and education networks have a lot to offer to schools, the healthcare sector and the arts, humanities and social sciences, especially when applications are present or are introduced in these sectors that put special demands on networks and services. Due to the introduction of videoconferencing or the increasing use of learning platforms and interactive whiteboards, network use in schools is becoming less basic and requires a reliable, secure infrastructure to access content or develop collaborations. In the arts, humanities and social sciences, novel and sometimes very innovative applications are made possible thanks to the large network capacities and advanced services that are offered. Research and education networks are instrumental for the work and research of scholars and artists. In the healthcare sector there is a similar need, even if, with very few exceptions, that sector is currently not served by NRENs.

Research and education networking organisations understand schools and their requirements much better today than a number of years ago. NRENs that serve schools have developed special schemes to provide them with connectivity and specific services. Such a specific approach does not exist for the arts, humanities and social sciences. Those communities are very demanding in terms of network infrastructure and services, but they may not be aware of all the possibilities offered by NRENs, nor are the NRENs aware of the requirements in this sector. If NRENs decide to serve the healthcare sector, they will definitely have to set up a special programme to understand the requirements of the sector much better.

The most important general recommendation resulting from the EARNEST study of the requirements of schools, the healthcare sector and the arts, humanities and social sciences is that the outreach from the research and education networking community to those three sectors should be enhanced. This will make NRENs aware of the use of networks and services by these end-users, and of their future requirements. It will also inform the sectors of the possibilities offered by research and education networks, and take away misconceptions about the limitations that these networks and the associated services are perceived to have.

The next step in such an outreach programme could be organisation of training for users. End-users in schools, the healthcare sector and the arts, humanities and social sciences, and other, similar communities are usually not very knowledgeable about networks and related services. This is especially the case if the services offered go beyond simple, low-capacity, best-effort Internet connectivity. Knowledge transfer from research and education networking organisations to novel users is very important. It will lead to a better understanding and a better use of networks and services by the individuals in the three sectors that are studied in this report. It will also inspire them to plan new forms of ICT use, which will put new challenges to research and education networks and thereby contribute to their further development.

5. Report on schools[3]

5.1 Introduction

National Research and Education Networking organisations (NRENs) were set up to provide network connectivity and services to the research community and institutions of higher education. Until recently, the NRENs largely focussed their efforts on this community, and schools were not really served by NRENs. However, a number of European policies influencing the use of ICT in schools have begun to change this.

Over the last decade, the use of ICT in education has become a higher priority, and the Internet has become a common learning and teaching tool in the classroom. In 2003, the SERENATE Summary Report stated that "*several national governments in Europe have initiated projects to provide network connections and services to schools…*". We are now four years on from that report, and we can see that more and more schools have been connected. In many cases, it is the NREN that takes responsibility for connecting schools; in other cases it is a separate, dedicated schools network.

Increasingly NRENs are connecting schools and are providing them with services and support. Schools present a different challenge to NRENs than other connected institutions, because they have a set of needs that is different from the needs of the traditional 'customers' of NRENs.

The overview provided in this report on schools follows on from the SERENATE studies. It looks at how the situation regarding network connectivity for schools has changed since those studies.

There are many educational establishments that could be described as 'schools'. However, this report will focus on compulsory education in primary schools and secondary schools (or 'lower secondary' education as it is called in some countries), since these are by far the most common types of school across Europe.

The overview will look at how schools are connected, what their needs are - both in terms of infrastructure and of support - and what services are offered by different NRENs. However, the main focus will be on the actual use of network connectivity by schools, particularly the pedagogical usage. The report is therefore written from the point of view of schools.

Additionally, the report will assess the impact that network connectivity and associated ICT use may have had on schools, both from the point of view of the learners and from the point of view of the teachers.

5.2 Methodology

The information for this overview was gathered by a number of different methods. Meetings were held with some of the NRENs that are active in connecting schools: ARNES (Slovenia), FCCN (Portugal) and HEAnet (Ireland). Further meetings were held with representatives from the French Ministry of Education and RENATER, and with colleagues at UNI•C responsible for policy relating to the Danish schools network, Sektornet.

3. *Author: Andrew Perry, Department for Children, Schools and Families, United Kingdom*

In addition to these meetings, a large amount of desk research was carried out, looking at what information in this area already existed in Europe.

The author of this report and the TERENA Secretariat organised a workshop in Paris on 10-11 February 2007, which brought together practitioners and NREN representatives to discuss and share ideas on the topics covered in this overview. The programme of the workshop and the list of attendees can be found in Appendix 1.

Finally, the subject matter was also discussed through TERENA's email discussion list on connecting schools[4].

The investigations leading to this 'Report on Schools' were carried out between June 2006 and April 2007.

5.3 Connecting schools

5.3.1 How are schools connected?

Schools obtain connectivity to the Internet in different ways. Some schools can be classified as 'early adopters': they purchased network connectivity directly from an Internet Service Provider or telecommunications operator before there were policies in place for the NREN to provide them with connectivity.

Countries such as Greece, Portugal and Denmark were at the forefront in this area and have had initiatives for connecting schools in place for a number of years. In Denmark, the programme was launched in 1993, and all schools were connected by 2000; the Portuguese initiative began in 1997. Slovenia has also followed suit, and England achieved its goal of having all schools connected in 2007.

As a result of a number of political factors (which are outlined in more detail later in this report), many other NRENs in Europe are now beginning to connect schools. Since the SERENATE report was published four years ago, the number of NRENs initiating policies to connect schools has significantly increased and the topic now features very highly on the agenda of many countries[5].

The three most common methods for schools to obtain network connectivity are:

- connection via the NREN;
- connection via a dedicated schools network;
- connection purchased from an Internet Service Provider independently of the NREN or schools network.

We can also see models that are a combination of two of these methods. For example, in Ireland and England network connectivity for schools is provided by telecommunications operators, but schools also receive a connection to the NREN and therefore benefit from the services that the NREN offers. In England, ten regional bodies (Regional Broadband Consortia) were created to procure connectivity on an 'aggregated' basis for all the schools in their region. By procuring on a bulk basis, they are able to negotiate significant discounts on the price, compared to the situation where schools would each purchase individually. Each Regional Broadband Consortium is free to obtain connectivity from any telecommunications operator, and it will look to choose the one that offers best 'value for money' for schools.

4. *<schools@terena.org>*

5. *See the TERENA Compendium of National Research and Education Networks in Europe at www.terena.org/activities/compendium/.*

In Ireland, a number of telecommunications operators had to bid for contracts to provide connectivity for schools. Six providers were awarded the contracts, and they provide free access to schools using the backbone of HEAnet, the Irish NREN. Routers for schools are supplied by another provider.

A fourth method is connecting schools via a Metropolitan Area Network or regional network that in turn is connected to the NREN. This is the case in France, for example. In that country, the administration of the school system is decentralised and relies on a collection of 'rectorats', which represent the central administration at the regional level. In most regions, the 'rectorat' organises the schools network (mostly through central procurement of DSL access). All traffic from the schools network is then is injected into the RENATER backbone at the regional level.

5.3.1.1 Connecting schools through NRENs

Schools represent a 'new' user group for NRENs, which have traditionally concentrated their efforts on universities and research institutions. Nevertheless, schools are a natural part of the research and education environment, because they share common needs with other parts of that community, and to a large extent all institutions in that community use network connectivity in a similar way. The most common usage in schools is the integration of the Internet in teaching and learning to help meet pedagogical aims. In turn, this allows the use of related technologies, such as interactive whiteboards and videoconferencing.

However, schools present their own unique challenges to NRENs. The number of schools is far greater than the number of universities in any given country, which can potentially present the NREN with problems of scalability of services and with problems of providing the necessary bandwidth to serve schools adequately.

There are some differences between Europe's NRENs in policies for connecting schools, but the policies have not changed much since 2003, although the total number of connections has increased significantly. Table 5.1 shows an overview, taken from the 2007 edition of the TERENA Compendium of NRENs in Europe.

	NREN allowed to serve secondary schools		NREN allowed to serve primary schools	
	Yes	No	Yes	No
EU / EFTA	25	5	23	7
Other countries	9	8	6	11

Table 5.1: NRENs allowed to connect secondary and primary schools

The table shows that the vast majority of NRENs could connect schools if they wished to do so. For those NRENs that connect schools, a large part of their total bandwidth is dedicated to that purpose.

The Compendium shows quite a wide difference between NRENs in the percentage of schools that they have connected. The lowest figure is for the Italian NREN, GARR, which had connected around 10% of primary schools and secondary schools. However, the policy to connect schools in Italy was still in its early stages, so it was expected that this figure would increase significantly. Some countries have total coverage of schools by the NREN: Bulgaria, Greece, Luxembourg and Portugal for secondary schools, and Portugal and England for primary schools.

It is interesting to note that there appears to be no 'middle ground': the figures were either very high or very low. It should also be noted that some countries did not appear on the list: Denmark, for example, even though almost every school in that country has network connectivity. This variation can perhaps be explained by geographic issues, which lead to high-speed connections or even basic symmetrical connections not being available in certain parts of the country, due to their location and the difficulties with installing the necessary carrier infrastructure. We can see this in certain parts of Ireland, for example, where due to their remote location a large number of schools have to rely on connections provided by satellite. The unique geography of Greece with its large number of islands explains why the level of dial-up connections used in schools in that country is still high.

5.3.1.2 Bandwidth to schools

While not all schools are connected via NRENs, virtually every school in Europe has access to the Internet. In most countries the rate is 100% or almost 100%, and the European average is 96%[6]. There is a wide variation in the bandwidth of these connections. This may be due to cost issues - it may be too expensive to provide schools with high-speed broadband connections - or geographic issues that make it very difficult to install the necessary infrastructure for anything other than dial-up connections in a specific area. This is a particular problem in rural areas.

Therefore, despite the equality of access to the Internet, there is some significant variation in the bandwidth of connections across Europe, with 'broadband' still quite a long way from being the standard for connections to schools. In this context, 'broadband' is a generic term used to describe a wide range of technologies delivering high-speed, always-on connections between computers and the Internet, thus enabling multiple messages or pieces of information to be sent between computers at the same time.

England is a notable exception with regard to broadband, because after having ensured that all schools had an Internet connection, a policy was implemented to provide all schools with a broadband connection of at least 2 Mb/s for primary schools and 8 Mb/s for secondary schools. (The actual wording of the policy stated that the connection should be appropriate to the schools' needs; therefore, there are some smaller schools that have ADSL connections, but these will be upgraded over time.) In some parts of the country there are schools with connections as fast as 100 Mb/s, but these schools are relatively few and deliberately requested a connection of this speed because they are heavy users of their bandwidth.

It is interesting that some of the countries that were at the forefront of connecting schools have low levels of broadband penetration. Greece is notable in this regard: despite the fact that almost 97% of schools have Internet access, only 13% of them have broadband access. This can be explained by the numerous geographical problems that a country such as Greece will experience when providing infrastructure to schools.

Ireland is also experiencing difficulties in this regard, as the majority of connections are provided by satellite link, which is very often unreliable.

Indeed, broadband has quite a low penetration rate across Europe, with only slightly over two thirds of all European schools having a broadband connection. Even within this category we see discrepancies. The most common form of broadband in schools is DSL (which arguably could be described not to be 'true' broadband), but there are some schools that have bandwidth as high as

6. *Benchmarking Access and Use of ICT in European Schools 2006. See http://ec.europa.eu/information_society/eeurope/i2010/docs/studies/final_report_3.pdf*

10 Mb/s. In the United Kingdom, only 4% of schools have a DSL connection, with the rest having at least 2-Mb/s bandwidth (this is explained by the government policy outlined above), whereas the average across Europe is 45%.

We must also be aware that there are a large number of schools that do not know what type of broadband connection they have, so in fact the figures for 'true' broadband could be much higher than those reported.

5.3.1.3 ISDN

A few years ago, ISDN connections were considered to be at the top end of what was available. With advances in technology in recent years, they are no longer seen in that same way. Nevertheless, for some schools they remain the best possible option, as true broadband is either prohibitively expensive or impossible to install due to geographic issues.

5.3.1.4 Dial-up Internet access

Dial-up access is becoming increasingly rare, with fewer than 10% of schools across Europe still relying on it for their network connectivity[7].

An important consideration is that although a school may have network connectivity, it is by no means certain that every computer in the school has access to this connection. It is common for only those computers in a specific area of the school to have Internet access - such as those in a computer suite or the library.

5.3.1.5 Schools networks

An alternative to NRENs providing connectivity to schools directly is for an administration to set up a schools network. Schools networks have a structure different from NRENs, as they exist to serve schools only. Thus, it might seem logical to assume that they are better able to offer more specific, dedicated services for schools.

There are some basic principles that are common to all schools networks, and indeed to NRENs. The most basic point is that they provide schools with a link to the Internet, which enables schools to do a number of things and offers them a number of benefits. A report from 2004[8] stated that there are four elements to effective schools networks:

- they are designed around an idea or specific purpose - i.e., connecting schools to the Internet;
- they focus on pupil learning;
- they create new opportunities for learning;
- they have dedicated leadership and management.

Perhaps the best known and most successful example of a schools network is Sektornet in Denmark. Although run by the same organisation that operates the national research network, Sektornet exists as a separate entity and there is very little collaboration between the two networks - the two are run and maintained by different groups of staff. As there was already an existing research network in Denmark, the possibility of connecting schools to it was discussed; however, there were three main factors which led to the creation of a schools network:

- schools were funded by the Ministry of Education, whereas universities fell under the remit of the Ministry of Science, Technology and Innovation;
- schools had very different needs than research institutions and universities;

7. *Ibid.*

8. *Ibid. - quoting from an unnamed DfES (United Kingdom) report of 2004.*

- it was felt that it was important to give schools their own network so that they would have a greater sense of ownership and influence on the way in which the network was developed.

An interesting point to note is that while Sektornet is intended for schools, the Danish government decided that all educational institutions in the country, including universities, could be connected to it. However, only those that came under the remit of the Danish Ministry of Education were connected free of charge; all others - e.g., universities - had to pay the full cost for their connection. (Universities use this network solely for administrative purposes, and they use the research network for all their other needs).

5.3.1.6 Connections purchased directly from Internet Service Providers

Because schools generally do not have a lot of money, particularly not for ICT-related activities, it is very easy for them to be tempted by connectivity offers from commercial Internet Service Providers. Very often they put economic issues over pedagogical ones, which is perhaps understandable. Very often the first budgets to be cut in schools are those for ICT, because cuts in that area usually do not involve job losses.

Schools will see offers from Internet Service Providers and compare the bandwidth offered against the price that they have to pay for it, and in the majority of cases, the Internet Service Provider will be the cheapest. This is attractive for schools, because very often they only have limited amounts of money to spend on ICT infrastructure.

However, such a comparison is not 'like for like'. While Internet Service Providers may seem tempting, the service provided by them is often limited to the provision of connectivity. And even connectivity cannot necessarily be directly compared. Commercial Internet Service Providers have to provide bandwidth to a very large number of customers, and this bandwidth has to be shared between all of these customers. As a result, there may be loss of service or slow download speeds or even limits on how much each customer can download.

NRENs are able to dedicate a large amount of bandwidth to schools, because they have a smaller 'customer' base. This means that Quality of Service (QoS) can be applied to ensure that the required bandwidth is available for applications such as videoconferencing when schools need it.

In general, Internet Service Providers do not see schools, despite their number, as a profitable user group and as a result they do not provide them with any dedicated services. So schools only receive the same package as a home user if they choose to go down this route. Some security and content filtering maybe included, along with email facilities, but beyond that, the services offered are limited.

Therefore, taking this option very often proves to be a false economy for schools. Nevertheless, in some cases commercial Internet Service Providers, whose main business is providing bandwidth, may be able to offer more bandwidth to schools than an NREN can (because the commercial companies own their own lines or have dark fibre, etc.).

For schools in some countries, the question of 'value for money' in obtaining connectivity is perhaps academic, as connectivity is provided free-of-charge by the NREN.

5.3.2 Models for schools connectivity

The models for the provision of connectivity to schools that we have examined all work successfully. It is perhaps unlikely that one model will work throughout Europe. For example, free provision is not possible in every country: in the United Kingdom, where there are 25,000 schools, the level of funding required could not be provided because the required amount (as quoted by British Telecom) far exceeded the total education budget.

In smaller countries the incumbent telecommunications operators generally do not see free provision to schools as a challenge to their market share, since the numbers are not significant enough to have any real impact on them. This might be different in a country where the 'market' of providing connectivity to schools is much larger.

By definition, governments are not telecommunications companies. In order to provide connectivity to schools, they need to work in partnership with one or more telecommunications operators. In some countries where there is little competition, the former monopoly provider is likely to be the dominant provider, so it is to be expected that it will be involved in initiatives for connecting schools.

In more competitive markets, giving such contracts to one company might result in a great deal of extra business and income for that company. In turn, this could lead to other companies challenging such a decision legally. It is important that a national government does not favour one company over others, as that is counter to the principles of open market competition.

5.3.3 Impact of connecting schools on NRENs

In smaller countries with very few universities, it is arguably natural for NRENs to connect schools because they are the main educational 'customers'. Nevertheless, schools still represent a different market from the one that the NREN was initially set up to serve, and hence connecting schools requires changes in organisation and funding for the NREN.

For example, in countries such as Slovenia and Luxembourg, schools are seen as natural customers for NRENs because there are very few universities in these countries; therefore, the impact of connecting schools is less than for an NREN that was originally set up to serve universities. In these cases, the decision to connect schools may require mostly the recruitment of additional staff to focus on services for schools, as well as securing additional funding to cover the additional costs.

There are also technical implications when connecting schools to NRENs.

The Danish model has little impact on the NREN, because the schools network is entirely separate from the research network. However, this required a new infrastructure to be set up, funding to be secured, etc.

5.4 Why should schools have network connectivity?

"*Pupils have a right to a network in school.*"[9]

9. *Russell Ingleby (ICT Co-ordinator, Westbrook School, England), EARNEST Workshop on Schools, Paris, 10-11 February 2007*

5.4.1 Motivations of schools

Schools need network connectivity for a number of reasons, ranging from simply being able to access the Internet, to using dedicated systems for management and administration purposes. On the pedagogical side, network connectivity enables schools to access the wide range of educational resources that are now available. For some schools, network connectivity is seen as something inevitable: other schools have it and therefore they need to have it as well, so that their pupils and teachers are not disadvantaged.

Network connectivity enables teachers to use a range of technologies to help their teaching. IT enables files to be shared, resources to be pooled and teachers to access learning resources from a range of sources via the Internet. In turn, this opens up new ways of teaching, for example, the ability to have videoconferences with other schools and to collaborate with them online.

In recent years, the level of Internet use by schools has increased substantially. Across much of Europe, using the Internet is no longer regarded as something desirable, but as an essential aid to teaching. Internet access and use has become widely embedded across the curriculum and is seen as a valuable tool to help teaching and learning.

5.4.2 Political factors

There are a number of political factors that also drive NRENs to provide connectivity to schools. Therefore, there may be a view that connectivity provided by NRENs is being forced onto schools to meet certain goals, rather than being something that schools want or need. These political factors include European Union agreements relating to the use of ICT in schools, which have made it necessary for schools to have network connectivity. The most important of these is the Lisbon 2000 agreement[10].

A number of policies in recent years have contributed to the increased use of the Internet, and ICT in general, in schools. Some of these are policies of specific governments, but a number are Europe-wide, initiated by the European Commission[11]. Key among these policies was the *e*Europe Initiative of 2000[12]. Its main objectives were:

- to bring every citizen, home and school, every business and administration into the digital age, and online;
- to create a digitally literate Europe;
- to ensure that the whole process is socially inclusive, builds consumer trust and strengthens social cohesion.

If we look at things in a cynical way, it could be suggested that perhaps the most important reason to connect schools is to meet the aims of the European Union, which made it a goal for schools to have network connectivity via an NREN. However, many countries had already implemented policies to achieve this before there was a political will from the EU that they would do so. Indeed, as a result of the Lisbon 2000 agreement, many countries that had connected schools in other ways, then agreed to connect them via the NREN.

10. *Presidency Conclusions of the Lisbon European Council of 23-24 March 2000. See www.europarl.europa.eu/summits/lis1_en.htm.*

11. *The agreements of Lisbon 2000, followed by Stockholm 2001 and Barcelona 2002*

12. *eEurope - An Information Society for all. Communication of 8 December 1999 on a Commission initiative for the special European Council of Lisbon, 23-24 March 2000. See http://europa.eu/scadplus/leg/en/lvb/l24221.htm*

5.5 The needs of schools

Although network connectivity in schools is not a totally new phenomenon, there are still schools that are having problems using the connectivity. Schools present something of a challenge to NRENs, because they are a unique user group in the sense that they have distinct characteristics and specific needs. Previously, NRENs did not have to think about how connectivity was being used, because the main requirement for most research organisations and universities is simply bandwidth to enable them to share data.

The needs of schools can be broken down into two categories: infrastructure requirements - the equipment that schools need - and service requirements - the content, applications and support that schools need to meet their pedagogical aims.

Network connectivity is now a basic requirement for schools to help them in teaching and learning, as well as for management and administrative purposes. For some schools, basic Internet access may be all that they need network connectivity for, but this is not true for most schools.

A key point to consider is which organisation should make the decision about the services that are offered to schools. Clearly, if the main use of network connectivity by schools is in the classroom, then the services provided to them should be linked to the pedagogical aims of the schools. It is felt that there is currently a gap in understanding between the technicians, i.e., the people in the NRENs, and the practitioners. If what is provided by the technicians is not what the schools want, then the schools will not use it. For example, schools will not use applications such as videoconferencing just for the sake of it: there has to be some educational gain for them in the process.

5.5.1 Infrastructure needs

Before any pedagogical service requirements can be considered and met, schools first need to ensure that they have the right infrastructure in place.

In order for network connectivity - and ICT - to be used in the school effectively and efficiently, there needs to be a reliable infrastructure that actually works. Teachers will not return to the computer if it did not work properly the first time they used it. If the infrastructure is reliable, then it will be used.

In addition, many teachers require training in the use of technology; otherwise it will just remain in the classroom unused.

Of course, although the requirements of schools are broadly the same, they will vary from school to school and from country to country. For example, just as schools have needs that are different from those of other users of NRENs, primary schools will have different service needs than secondary schools. Special schools will have their own particular, specialised needs.

The curricula in primary and secondary education are different. Therefore, resources developed for primary schools will not necessarily be suitable for secondary schools, because they may be at too basic a level. The teaching methods are also different, with the pedagogical aims being more advanced for secondary schools. The learning of foreign languages is an example. They are not taught at primary level in all countries, but where they are, it will obviously be at a more basic level than in secondary schools. As a result, a primary school may not need to have videoconferencing services, but a secondary school may wish to use this technology to link to a school in another country in order to enable its pupils to talk to other pupils in the language that they are learning.

A subject such as computer science is unlikely to be taught at primary level, so there is perhaps less need for primary schools to have a dedicated PC suite for teaching this subject (or indeed other subjects). The number of computers that a primary school needs is also likely to be smaller because of the smaller number of pupils.

However, there are common requirements for schools, such as interoperability to enable their different systems to 'talk' to each other, and to use or share common applications.

For many schools, a very large issue facing them is technical support, or the lack of it within the school.

5.5.2 Service needs

Taking the United Kingdom as an example, the services that schools need can be categorised as follows:

- access from the school to local, regional, national and global educational resources; this access is needed by both teachers and pupils;
- connection to the local authority (municipality) - for local resources and support;
- connection to other schools, universities and colleges - for collaboration and access to resources;
- connection to the Internet - to access resources that may not be available via the 'Education Network';
- access to educational resources from home.

The needs of schools consist of more than just resources, or the ability to access resources. There are also certain expectations about the level of service that schools will receive from their connection.

Rob Symberlist of JANET(UK) suggests[13] that schools expect that their connections will be:

- safe - with some form of content filtering;
- secure - with authentication and authorisation procedures in place, such as Shibboleth;
- trusted - with approved, high-quality resources available to them;
- reliable - teachers will not use connections that are unreliable;
- standard - across schools to ensure interoperability and enable collaboration.

The most important service need is an infrastructure that works. For teachers to have confidence in the infrastructure and for them to use it, it must be reliable. They are unlikely to incorporate the use of network connectivity into their teaching if it does not work whenever they need it to. When the infrastructure does break down, schools need to know that technical support is available to fix the problems.

This applies to the PCs in schools in the same way as it applies to the Internet connection. Schools that want to use videoconferencing need to be assured that the bandwidth that they have is sufficient for the purpose and reliable enough for conferences to take place without any loss of service. For these schools, QoS is an important requirement.

Schools are also reassured if they know that some form of content filtering is in place to prevent pupils from accessing material that they should not access. In some countries - Luxembourg, for

13. *Rob Symberlist (UK Schools Strategy Group Manager, JANET(UK)), Second TERENA Workshop on Connecting Schools to NRENs, London, 24-25 October 2005. See www.terena.org/activities/schools/workshop-2/technical-group-RS.pdf* example - the decision whether to have filtering in place is with the school. In Ireland, the NREN offers the filtering service, but the level of filtering is tailored for each school.

5.6 NREN services

NRENs have been offering services to their 'traditional' customers such as universities and research institutions for many years. These services may not be suitable for schools, or may not be as comprehensive as those required by schools. Schools and universities are very different, and the services that they need are also different. Evidence suggests that the main requirement of universities is bandwidth.

Indeed, the main service that NRENs offer is bandwidth. In principle, bandwidth could also be obtained from a commercial Internet Service Provider. However, as discussed earlier, even this is not a 'like for like' comparison.

What services can NRENs provide to schools? NRENs can help the schools sector by offering a wide range of services, which can be categorised[14] as follows:

- Services that are not otherwise available, locally or nationally:
  - access to the resources of universities and colleges;
  - connections to schools connected to other NRENs;
  - access to research groups and national resources (museums, galleries etc.);
  - expert support, advice and guidance (for videoconferencing etc.).
- Services that could meet a common need within the sector:
  - content services;
  - media streaming;
  - videoconference management;
  - collaboration services;
  - authentication and authorisation (Single Sign-On).
- Common services that are also needed by other sectors:
  - gateways;
  - directory services;
  - videoconferencing services.

Besides these services, NRENs can also offer 'value-added' services to schools.

As stated by Rob Symberlist, the natural conservatism of school systems suggests that from the services potentially offered by NRENs, those that will be adopted will be those that support existing needs, and not unproven future ones that appeal to the early adopters and enthusiasts. The term 'advanced services' needs to be explained in this context: are they value-added services, technically advanced services or pedagogically advanced services?

Not all NRENs offer all of these services, and usually those in smaller countries offer more assistance and support to schools since they have fewer schools to work with. For example, it is not possible in the United Kingdom that the NREN helps every school configure its router, because there are not enough resources available.

14. *Presentation by Rob Symberlist at a Birds-of-a-Feather session at the TERENA Networking Conference 2005, Poznan, 7 June 2005. See www.terena.org/activities/schools/tnc-2005-bof/ukerna.pdf*

It is an important question how much NRENs should offer to schools. It is not obvious that the same services should be offered by all NRENs, because differences in education systems may mean that schools need different things. On the other hand, for the most part, schools across Europe are using network connectivity and ICT in similar ways in the classroom, so perhaps there is a good argument for uniformity of services.

Currently there are differences in what NRENs offer; this may be linked to what they actually are able to offer to their schools technically and geographically. The number of schools in a country affects this choice, as does the infrastructure that schools possess.

The next sections look at services offered by NRENs in Europe to see if there are any common features and services that could be applied uniformly across Europe.

5.6.1 ARNES (Slovenia)

ARNES in Slovenia is an NREN that is able to offer a great deal of support to schools. ARNES guides schools through the whole process, from obtaining connectivity to supporting them in its use, and offering services to them.

Over 90% of schools in Slovenia obtain their connectivity from ARNES. They are connected directly to a Point of Presence (PoP) operated by ARNES. Assistance is offered to schools in finding the connectivity solution that best meets their needs, be it ISDN, ADSL or a faster connection. In addition, help is offered in finding and purchasing a router for the school. A set of technical standards for local-area networks in schools has been developed, which schools can follow when setting up their network.

Following the purchase of the router, ARNES configures it for each school according to the school's needs - which means that more bandwidth can be allocated to ensure Quality of Service for videoconferencing, for example. Should the router break down, a school can return it to ARNES to be repaired and reconfigured.

Once the router has been installed in the school, IP registration is handled by ARNES, along with domain name registration and DNS.

Schools receive email accounts for the teachers and pupils (although currently some of these are being closed down), as well as Web hosting for the schools' own webpages and email filtering. In common with many NRENs, ARNES does not offer content filtering to schools. It is felt that this is a decision for schools to make themselves and that the same policies should not be applied to all schools since not all schools will access the same kind of webpages or use the same type of applications. For example, in some cases, Web filtering and providing firewalls can prevent a school from being able to use videoconferencing.

Because ARNES provides the connectivity, schools often phone ARNES as a first line of support when there is a problem with the connection. However, dealing with such problems is the responsibility of the telecommunications operator that provides the lines to ARNES on a leased-line basis.

5.6.2 Sektornet (Denmark)

The Danish schools network, Sektornet, also provides a wider range of services than might generally be expected of an NREN. It aims to be an overall solution for schools: connectivity (a phone line and router) is included as part of the package when schools purchase Sektornet.

Because Sektornet is a dedicated schools network (although other educational institutions can connect to it as well), the services it provides are specifically designed for, and targeted at, schools. One of the most important services offered by Sektornet is a mail and conferencing system for teachers known as 'Skolekom'[15]. Schools automatically receive this service when they purchase a connection to Sektornet.

Secondly, as in Slovenia, schools receive a Web hosting service (in this case called 'Web-hotel'). It is a requirement for all schools in Denmark to have their own webpages, and this service provides them with a place to host their sites.

Also like the services offered by ARNES, DNS is offered through Sektornet. This is one example (perhaps the only one) of an area where Sektornet collaborates with the Danish research network: each of the networks operates its own primary DNS service, but provides back-up for the other network.

Another crucial service available in Denmark, arguably the most used one, is a schools intranet system called 'SkoleIntra'[16]. This is the dominant intranet service in the country, with approximately 90% coverage.

Denmark operates a Single Sign-On system known as 'UNILogin'. Users only require one username and password to access all of the services that they subscribe to. A number of other NRENs are looking at providing a similar service, using another method of authentication and authorisation, e.g., Shibboleth.

Danish schools also receive a suite of support services through the network. This is different from the support provided to other educational institutions as the needs of schools are different in this regard. Unlike with the Danish research network where support is provided by telecommunications providers, schools receive support directly from UNI•C, which runs Sektornet. As part of this support service, one member of staff in each school receives training, so that he/she can act as a contact person in the event of problems. This is advantageous as it means that only one person ever deals with issues and there is less chance of miscommunication or misinterpretation of issues and advice.

It may be that ARNES and Sektornet are able to offer the services mentioned above while a larger NREN may not be able to do the same, because these two networks have a comparatively small number of schools to support.

5.6.3 FCCN (Portugal)

Portuguese schools have access to a telephone helpdesk to help them identify and solve problems with their network. This helpdesk is the primary interface for schools. The helpdesk staff are specialists in dealing with the problems commonly faced by schools networks and are able to provide an efficient and effective service to the users.

Each school also has access to a private area in the central information system where it can access all relevant data for the school, including administrative data (which can be updated). From this private area it can open or close email boxes, and access data about network usage.

15. *http://web.skolekom.emu.dk*
16. *www.skoleintra.dk*

Like some other NRENs, FCCN also provides a router-configuration service to schools. Each router can be configured with desired levels of content filtering, or QoS for specific applications. The service is provided by the NREN and then the router is sent out to the school. The helpdesk can help solve any problems that occur with the router after it has been installed at the school.

5.6.4 HEAnet (Ireland)

HEAnet is another NREN that offers centralised network management and monitoring services. It is able to monitor schools' connectivity to check for connection problems and loss of service, and can alert schools to any issues. Each school also has access to a range of Web-based applications for monitoring their network. These applications are configured differently for each school, according to the school's own needs.

HEAnet configures each school's router. As with FCCN in Portugal, each one is configured according to what the school wants. As there are a range of providers supplying connectivity to schools and a number of ways in which schools get their connectivity (satellite, ADSL etc.), the routers must also be configured appropriately for the relevant form of connectivity.

Security and content filtering is also offered, because it is a requirement of the Irish Education Ministry for schools to have some form of content filtering. When the router is configured by HEAnet, the required level of content filtering is set up. Again, this is different for each school, although with some common aspects for all schools.

5.6.5 Possible common NREN services

There are some services that could potentially be offered by all NRENs, but are not yet delivered.

5.6.5.1 Authentication and authorisation / Single Sign-On

A Single Sign-On system enables users to use one username and one password to access a wide range of applications and services. Not all NRENs currently offer this service, and there is a wide range of possible solutions available on the market, mostly based on open-source technology. Sektornet provides such a service for schools, as does ARNES in Slovenia. The case can be made that it is a service that all schools need and that should therefore be provided by all NRENs.

5.6.5.2 Management of local-area networks

Many schools lack staff with the technical knowledge required to carry out day-to-day management of the school's Local Area Network (LAN). They need someone to support them in setting up and managing the local network. This is currently not a service offered by NRENs, apart from one or two exceptions.

Schools need to have confidence in their LAN in order to make effective use of their network connectivity. The responsibility for LAN management currently lies with the schools. In some cases it will be carried out by a technician employed by the school. In other cases, a teacher may combine this role with his/her teaching responsibilities. A common solution, particularly in the United Kingdom, is for this task to be outsourced to a technical support specialist or local authority.

This is an area that has prompted debate in the NREN community, and it has been suggested that this is perhaps a task that could be handed over to NRENs as they may already have the required technical knowledge. Of course, taking on such a responsibility would have significant impact on the

NREN - financially and in terms of resources. It also marks a departure from NRENs' traditional areas of responsibility and support.

If schools are to incorporate the use of network connectivity into their every-day tasks, it is important that they have confidence in the infrastructure. Having the technical experts at the NREN configure their LAN for them would give them such confidence, and they would also know that if problems occur, effective support is on hand. As we have seen, some NRENs have taken the first step in this process and are already helping schools not only configuring their routers, but also offering them purchasing advice.

It is probably not realistic for NRENs to offer full LAN management, but NRENs can and do offer technical advice in the form of network specification documents, which provide help and guidance on purchasing and setting up a number of systems in schools, including networks.

5.7 What do schools use network connectivity for?

Previously, schools saw the Internet as something desirable that only a few schools had. Now, it has become an essential tool for teaching. To a certain extent, network connectivity has always been used in the classroom, but initially it was reserved for the teaching of ICT (computer science) as a subject.

In 2004, it was already stated in the United Kingdom that *"The majority of computers in primary, secondary and special schools were used for teaching and learning"*[17]. If we look at the 2004 evidence from the United Kingdom, we can see that the percentage of teachers using ICT for teaching and learning was as follows[18]:

- primary schools: 92%;
- secondary schools: 70%.

It is perhaps surprising to see that the percentage was higher in primary schools than in secondary schools, but this can possibly be explained by the wider curriculum in secondary schools and a lack of resources for certain subjects at the secondary level, due to the more advanced curriculum.

Looking at the situation across Europe as a whole, we can see a similar pattern to that reported in the United Kingdom in 2004. It was reported in 2006 that *"computer use for educational purposes is at very high levels in secondary schools almost everywhere in Europe (between 90% and 100%), a little lower in primary schools…"*[19]. In this 2006 survey, there were very high figures reported for the number of teachers across Europe who had used ICT in the classroom in the last twelve months.

As is to be expected, in some countries ICT is most commonly used in teaching ICT or computer science. However, as the availability of resources for other subjects increases, ICT is now being embedded more widely across the curriculum. This is particularly true in the teaching of science and mathematics, and also in design and technology. However, it must be stressed that this is not the case in all European countries, because schools in the new EU member states are not very advanced

17. *Becta and Department for Education and Skills, ICT in Schools Survey 2004. See http://partners.becta.org.uk/upload-dir/downloads/page_documents/research/ict_in_schools_survey_2004.pdf*

18. *It is of course likely that these figures have changed since 2004.*

19. *Benchmarking Access and Use of ICT in European Schools 2006. See http://ec.europa.eu/information_society/eeurope/i2010/docs/studies/final_report_3.pdf* in the integration of ICT and the Internet into the teaching of most subjects. In comparison, many of the other member states have made the use of ICT and the Internet much more a key part of the teaching of most subjects across the curriculum[20].

Research indicates that across the European Union, the Internet, and ICT, is integrated into the teaching of 'most' subjects in 75% of schools, with some radical differences between the member states. For example, the United Kingdom was reported as having 94% of schools integrating ICT into teaching across the curriculum, while Greece was the lowest at almost 42%. These differences can perhaps be explained by the bandwidth of schools, since every school in the United Kingdom had a broadband connection and the majority of schools in Greece still had a dial-up connection[21]. Another reason for the differences in the figures is the availability of resources and materials that teachers can use.

The figures are roughly the same as those that we see when looking at the numbers of teachers who say that they have used a computer in class in the last twelve months. Here again we see that the United Kingdom has the highest number and Greece has one of the lowest figures.

What does this actually mean? We know that computers are used in lessons, but how are they used, and how do they support the pedagogical aims of teachers or specific subjects?

ICT is not intended to replace traditional teaching methods but to enhance them, and there are a number of ways in which that is done. Clearly, network connectivity should not be used just because it is available in a school, but it should be used in a way that will meet the pedagogical aims of the school.

5.7.1 Network connectivity and pedagogy

Effective teaching is linked to sound pedagogical practices, but pedagogy is more than just simply teaching itself. Pedagogy is defined as 'the study of the methods and activities of teaching'[22]. Each subject of the curriculum has its own pedagogy, and this section looks at how network connectivity and ICT can be used to support pedagogy.

As far back as 1990, it was suggested that the use of ICT was changing the pedagogical role of teachers[23]. Network connectivity can help meet the pedagogical aims of a teacher, or of a school as a whole. It should not be seen as a replacement for traditional teaching methods, but as a way of enhancing them. The way in which network connectivity and ICT are used in the pedagogical practice of teachers ranges from small enhancements to their normal teaching practice, to more wide-scale changes in their approach to the teaching of a particular subject - this could mean that instead of the teacher demonstrating something to a class on an interactive whiteboard for example, the pupils will do this instead, and use it to display their assignment or homework to their fellow pupils.

It has been suggested that there are a range of practices that should be part of teachers' pedagogical frameworks if they are to integrate ICT and the use of network connectivity effectively into teaching, learning and the curriculum. These include the need for teachers to:

- understand the relationship between a range of ICT resources and the concepts, processes and skills in their subject;

20. *Ibid.*

21. *See Section 5.3.1.*

22. *Oxford English Dictionary*

23. *Becta and Department for Education and Skills, ICT and Pedagogy, A review of the research literature - quoting a report by Hawkridge ('Who needs computers in schools, and why?'). See http://publications.becta.org.uk/download.cfm?resID=25813*

- use their subject expertise to select appropriate ICT resources, which will help them meet the specific learning objectives; this includes subject-specific software as well as more generic resources;
- be aware of the potential of ICT resources, both in terms of their contribution to pupils' presentation skills, and in terms of their role in challenging pupils' thinking and extending their learning in a subject;
- develop confidence in using a range of ICT resources, via frequent practice and use beyond one or two familiar applications;
- appreciate that some uses of ICT will change the ways in which knowledge is represented, as well as the way the subject is presented to pupils and engages them;
- know how to prepare and plan lessons where ICT is used in ways that will challenge pupils' understanding and promote greater thinking and reflection;
- recognise which kinds of class organisation will be most effective for particular learning tasks with ICT, for example: when pupils should work on their own, how working in pairs and groups should be organised, and when ICT should be used for whole-class teaching.

In order to implement the use of network connectivity successfully into subject teaching, the level of subject knowledge of teachers must be sufficiently high for them to understand how to use connectivity in the most appropriate and suitable way for the content of the lesson, and how this usage can help to get the key aims of the lesson across. What is suitable for one subject is not necessarily suitable for another subject, i.e., what works best to teach mathematics may not work best to teach history, due to the different nature of the subjects. This is also true because the pedagogical nature and techniques are different for each subject.

For example, in science or mathematics it is possible to use simulations to illustrate certain ideas or experiments. This may be through modelling or through a resource obtained via a resource portal. This is clearly not suitable for the teaching of history. For the teaching of local-language literature, it may be appropriate to use interactive video to help pupils understand a specific novel or play.

The study of foreign languages has incorporated the use of technology for many years, with language laboratories and the use of audio material enabling pupils to hear the language and to practice it. Therefore it lends itself well to the use of technology. In particular, technology is used to aid the teaching of pronunciation skills by pupils recording their own voices and playing them back, and also through videoconferencing with native speakers. Reading and writing skills can also be taught, and possibly assessed, using technology such as language games that can be found online.

If we look in more depth at the teaching of English in schools in the United Kingdom, we can see a difference between the ways ICT is used in the primary curriculum and the secondary curriculum. In primary English, there is a focus on word processing by pupils, for example, to write stories. This is not a radical change in teaching methods per se, but a replacement for the traditional method of pupils writing stories by hand. In secondary schools, word processing is also used, but it is coupled with the use of videos, and the pupils are less supervised than they might be in primary classes - they have more freedom.

The use of ICT in the teaching of mathematics should not just focus on helping pupils to find the right answer, but also on helping them understand the reasoning and principles required to find the answer.

Mathematics is another subject with key pedagogical differences between primary and secondary levels. There is a tendency for primary mathematics learning to be more focussed on games-type software and applications involving simple programming. In secondary mathematics, where the curriculum includes topics such as geometry, the use of network connectivity is incorporated to help pupils' understanding of this area, through the access of online resources.

Teachers' pedagogical approaches to the use of ICT are affected by a number of factors. The most important of these is their own knowledge of their subject. Those with a more extensive knowledge of the subject will select resources and incorporate the use of network connectivity more carefully, rather than just use them to present questions or problems in a different way.

Of course, pedagogical practice changes, and the use of network connectivity must also change in order to continue to support teaching and learning effectively.

The most obvious use of network connectivity in schools is the use of the Internet during lessons. This may take many forms - a teacher may ask the students to use the Web to research a specific topic, or the teacher may access a particular resource on a specific website.

In some cases this goes beyond the incorporation of connectivity and ICT into classroom lessons. In France, it is an integral, and indeed compulsory, part of the curriculum at all levels for pupils to learn how to use the Internet. This is assessed through the IT and Internet proficiency certificate[24], which tests a range of ICT-related competencies and assesses pupils against these competencies. There are two levels of assessment, one for primary schools and one for secondary schools. The use of IT and the Internet is one of the seven areas of learning set out in the 'Socle commun' decreed by the French government in 2006[25].

There are also a number of other ways in which network connectivity can be used in schools, as described in the following sections.

5.7.2 Resource portals

It is important that teachers have access to good-quality online resources and content in order to embed ICT into their teaching. In many countries there is a lack of suitable resources, and in some countries there is not a lot of information to connect to.

Some countries have developed portals to bring together a range of educational resources across all subjects and make them available to teachers. These resource portals enable teachers to search for resources from a range of criteria, and those resources can then be used in the classroom.

5.7.3 Videoconferencing

Almost all NRENs offer videoconferencing services to schools. It is a service that is used in a lot of countries, but it is by no means common in every school. In Denmark, for instance, there are very few examples of schools using videoconferencing, but in the United Kingdom a number of schools use it in the teaching of modern foreign languages.

Videoconferencing enables schools to communicate with others in the same country, or in a different country. It also enables schools to link up with museums or research institutions.

24. *Brevet informatique et internet (B2i)*

25. *Le socle commun des connaissances et des compétences. See http://media.education.gouv.fr/file/51/3/3513.pdf*

Although the number of broadband connections has increased, there has only been a very small increase in the number of schools that have taken up videoconferencing services in the last few years. This may be because schools do not yet realise the potential of this activity or in some cases because their bandwidth is not adequate for hosting good-quality conferences.

The digital divide is a problem to be overcome in order to spread the use of videoconferencing. For many schools, videoconferencing is not an option, and other schools will not do it just for the sake of it. There has to be some educational gain for them. Although it is a valuable learning tool, schools have other priorities.

5.7.4 Websites

In addition to the common and expected use of network connectivity, some schools are demonstrating more 'advanced' usage. Increasing numbers of schools are developing their own websites. Indeed, in Denmark it is a government policy for every school to have its own website. It has been reported that as many as two thirds of schools in Europe have their own website. However, such a site may consist only of a homepage and nothing else, and this high figure can also be attributed to certain policies, such as the one in Denmark.

5.7.5 Interactive whiteboards

The use of interactive whiteboards (IWBs) in classrooms is increasing. There have been a number of initiatives in the United Kingdom that provided funding for schools to purchase IWBs, and recently in Denmark there have been some pilot schemes operating to gauge their effectiveness as teaching tools.

Network connectivity facilitates the effective use of IWBs, enabling teachers to access resources easily.

5.7.6 Learning platforms

Learning platforms are known by a number of different names: Learning Management Systems, Virtual Learning Environments and Managed Learning Environments. All of them are different versions of the same product, which enables pupils and teachers to have access to the same system and the same resources at home as they do in school. This means that pupils can email their homework to teachers, teachers can comment on assignments and parents can monitor the progress of their child.

Learning platforms are still a relatively new phenomenon across much of Europe, but their use is beginning to increase. The United Kingdom has made it a goal for every school to have a learning platform with at least 'basic functionality' by 2008, and a system has been in place in Denmark for a number of years (SkoleIntra). The introduction of learning platforms for schools can lead to problems. As there are a very large number on the market, unless one single system is implemented in every school - which is suitable and achievable only in a small country with a small number of schools - problems of interoperability begin to emerge: the different systems cannot talk to each other and consequently schools cannot exchange and share data with each other.

5.8 Barriers to the use of network connectivity

Despite the developments sketched above, the use of network connectivity in the classroom is not yet ubiquitous. There are a number of reasons that prevent schools from fully integrating network connectivity into teaching.

Not all PCs in schools are connected. For example, in some schools it is only the computers in a dedicated PC suite or in the library that have network connectivity. This means that they can only be used by one class at a time, and consequently teachers cannot incorporate ICT into all of their lessons.

Low bandwidth is also a problem, because it has the effect that schools are not able to use all of the applications and services that they would like to use. A statement about 'low bandwidth' could refer to a number of different issues; for example, the bandwidth may be too low for the school's actual needs and it may not be possible, for geographical or economic reasons, to purchase more bandwidth. However, in the current context 'low bandwidth' refers to a connection of less than 2 Mb/s, which is considered to be the minimum for effective use of applications such as videoconferencing. Therefore, it could refer to a dial-up connection or a 512-kb/s ADSL connection, for example.

However, the biggest problem facing schools is that they may be unable to purchase reliable infrastructure because of a lack of money. As mentioned above, teachers will not use technology if it is unreliable and does not work the first time that they try to use it.

5.9 The impact of network connectivity on schools

The investment made by various governments in network connectivity and ICT needs to have some visible results in order for it to be justified and to continue. Teachers can still teach even without network connectivity in their schools, because the resources exist in the form of books, DVDs etc.

The presence of ICT in schools should enhance existing teaching methods, not replace them. ICT does not automatically turn a bad teacher into a good teacher, but it can help good teachers teach even better.

However, the question needs to be asked whether network connectivity actually makes any difference to schools. Based on the information available, the answer is affirmative - in many ways.

While ICT as a whole has had an impact, we can also see that different types of infrastructure and tools - broadband, interactive whiteboards etc. - have had their own effects on different aspects of the teaching process. When different types of technology are combined, the impact becomes much greater.

5.9.1 The impact on teachers

First of all, ICT makes aspects of teachers' jobs easier and more efficient. Teachers can create and share resources with other teachers, or use resources created by another teacher and thus save time on lesson preparation. In a 2004 survey, nearly three quarters of teachers who were able to answer the question reported that ICT had reduced their workloads, at least partly[26].

	Primary schools	Secondary schools
Substantial reduction	9%	7%
Some reduction	60%	59%
Little/no change	23%	26%

Table 5.2: Reduction of teachers' workload due to ICT

26. *Table 5.2 is reproduced from the ICT in Schools Survey 2004. See http://partners.becta.org.uk/upload-dir/downloads/page_documents/research/ict_in_schools_survey_2004.pdf*

By being able to access resources online, an extra dimension can be added in the classroom and this can increase the motivation and participation levels of the pupils. This applies in particular to students with special educational needs, who may not be able to participate in a 'traditional' lesson.

5.9.2 The impact on learners

The impact of ICT on learners is arguably more powerful than the impact on teachers. As they are the main users of ICT in the classroom, it should perhaps be expected that there will be an impact. While there is not evidence from every country in Europe concerning this issue, the available research results are certainly a powerful argument for network connectivity in schools.

Of particular note is data from the United Kingdom (although centred on schools in England only) and Scandinavia, which provides evidence that ICT can increase the achievement and attainment levels of pupils in a number of subjects.

The impact of ICT is linked to the teachers' confidence in using the technologies in the classroom, and where it is used, it must be used effectively. Simply putting computers into a classroom and allowing pupils to access the Internet will not improve the attainment levels of pupils. Equally, ICT must be used to meet specific objectives, and not just as an alternative way to present work.

5.10 Summary and conclusions

5.10.1 Summary

An increasing number of NRENs are now providing network connectivity to schools. In addition, a number of services are provided to schools to support their use of this connectivity. The services that are offered vary, but there are some that are offered by almost all NRENs.

The way in which connectivity is provided to schools varies across Europe, as does the level of bandwidth available to schools. There are a number of reasons for this. Political will has had some influence, but it is likely that NRENs would have connected schools anyway.

The evidence gathered shows that network connectivity is widely used in schools, and that it can make a real difference to the way teachers teach and pupils learn. When used effectively, network connectivity has a positive impact on pupils' attainment and achievement levels. When used in the right way, it can be a valuable pedagogical tool.

Much of the evidence relating to network connectivity in schools that was available for this report came from a few countries, with most of the evidence coming from the United Kingdom and the Scandinavian countries.

5.10.2 Conclusions

Network connectivity opens up a wealth of possibilities to teachers. Potentially it may result in a radical change in their teaching methods, but more commonly, it will be used to enhance already effective teaching methods.

Schools need to have confidence in their infrastructure before they will use network connectivity in the classroom. Simply put, if it does not work, then teachers will not use it. Effective technical support is therefore very important to them.

From the point of view of educational needs, the services offered need to be linked to the educational aims of schools. Schools cannot be forced to use videoconferencing if there is no educational benefit for them.

From a pedagogical point of view, the use of network connectivity is linked to the teachers' understanding and knowledge of their subject. As pedagogical practice changes, so the use of ICT needs to change accordingly, in order to ensure that educational goals are met.

To develop their value for schools in the future, NRENs should look into offering additional services to schools. However, this has clear implications in terms of staffing and finances, and some of the possibilities might be a long way off.

6. Report on the arts, humanities and social sciences[27]

6.1 Introduction

This report focuses on a community of users defined as the 'Arts, Humanities and Social Sciences' (AHSS). The so-called 'inclusiveness' of research networks - i.e., extending their connectivity and services to institutions and persons outside their traditional user community of researchers, teachers and students in universities and other higher-education institutions - was already a topic in the SERENATE study of 2002-2003. One of the SERENATE reports[28] bundled a number of case studies[29] to describe the inclusion of some of these 'new users'. However, the AHSS community was only described by the issues that arise in connecting art schools, libraries and museums.

Therefore it was decided that the study reported on in this chapter would examine these issues in more detail. The study addressed questions such as what the AHSS communities use the network for, whether they are connected via NRENs and if so, why, and whether future needs can be identified.

Since the publication of the SERENATE Summary Report at the end of 2003, consecutive editions of the TERENA Compendium of National Research and Education Networks in Europe have reported a significant increase in the amount of available bandwidth. Besides additional plain bandwidth, many new services have been introduced by the NREN community in the years since the SERENATE study. This report on the arts, humanities and social sciences examines how independent centres or departments of arts, humanities and social sciences at universities have put these new services to work. The report provides examples of network use and elaborates on the technical implications for the network infrastructure.

6.1.1 Scope

The areas that for the purpose of this report have been included as part of the 'arts' category are shown below. The classification was made on the basis of a combination of authoritative sources and discussions with the community.

- Architecture
- Arts and Visual Arts
- Crafts
- Dance
- Decorative arts
- Design
- Drawing
- Film
- Language
- Literature
- Music
- Opera
- Painting
- Photography
- Poetry
- Sculpture
- Theatre and performing arts

The following communities were included in the category 'humanities and social sciences':

- Anthropology
- Communication
- Cultural studies
- Development studies
- Economics
- Education
- Geography
- History
- Linguistics
- Political science
- Psychology
- Social policy
- Social work
- Sociology

27. *Authors: Sabine Jaume-Rajaonia (RENATER) and Cătălin Meiroşu (TERENA Secretariat)*
28. *Sabine Jaume-Rajaonia et al., Report on examples of extension of research networks to education and other user communities. See www.terena.org/publications/files/SERENATE-D15.pdf*
29. *For example, 'French Schools of Art, Communication Networks and RENATER'*

6.1.2 Methodology

The study was carried out between November 2006 and June 2007. Historically, there have been no intensive contacts between the NREN and AHSS communities. For the study, it was therefore necessary to develop links by:

- searching the Internet;
- requesting feedback from NRENs;
- interviewing people involved in the AHSS communities (see Appendix 2);
- obtaining responses to a short questionnaire sent to identified contact persons;
- attending events.

The questionnaire was sent to about thirty people working in the fields of arts, humanities and social sciences in Europe. The questionnaire was intentionally kept short: it was designed to open discussions and to provide the authors with ideas and topics for investigation. The response rate was 45%. Although the number of responses was not sufficient for a quantitative analysis of the activities in the field, the answers to the questionnaire provided a useful list of up-to-date examples of network-related activities in the AHSS.

6.1.3 Additional considerations

Activities such as browsing and searching the Web for information, collaborating via email, staying in contact via instant-messaging clients, downloading documents and applications using FTP (or similar) repositories are now part of the daily life of scholars in any domain. The infrastructure to support such use is part of the standard services offered by NRENs to connected institutions. In this report, the authors chose to consider only the use of advanced network-related technologies. These technologies will be by far the main drivers for advanced services and increasing use of bandwidth.

The report is presented in three main parts. The first part (Section 6.2) provides an overview of the network usage in the AHSS, based on examples of experiments or activities. The second part (Section 6.3) focuses on technical aspects related to the use of connectivity and services provided by NRENs. The last part (Section 6.4) looks into the use of network services by the AHSS community in the medium-term future.

6.2 Use of network services by the AHSS community

The AHSS community uses network services for supporting a wide variety of content-centric purposes, including creating, producing, communicating, publishing, teaching, searching and archiving materials. More and more information and sources of inspiration have become widely available and easily accessible thanks to the development of broadband Internet. Our rich European cultural heritage is thus made accessible in digital form to artists and researchers as well as to the general public. In such an environment, the authors of this report expected to observe a change in the traditional research and creative practices of the AHSS community. This would lead to the development of new types of collaboration or sharing of information, based on high-bandwidth networks.

Our survey and interviews with well-established stakeholders in the AHSS field suggested that several domains are more advanced in embracing network services and digital technologies than others. We chose to illustrate the use of network services by the AHSS community from the following perspectives:

- performing arts;
- virtual environments;
- databases.

6.2.1 Performing arts

Recently, the field of performing arts was the scene of several pioneering examples of the use of network services. The visual aspect of these experiments helped disseminate the results and convey a positive message on the capabilities of high-speed research networks.

In 2006, Ann Doyle (Manager of the Arts and Humanities Initiative[30] at Internet2) gave an excellent presentation at the TERENA Networking Conference about the use of the Internet2 infrastructure and services in these fields. She mentioned master classes (for music, but also for choreography) and live-performance events (orchestra rehearsal, ballet). Some of these events involved successful transatlantic network connections, built over Internet2 networks, GÉANT2 and the networks of NRENs in Europe:

- In January 2006, with the participation of GARR (the Italian NREN), a viola master-class video-lesson was held by Master Luigi Alberto Bianchi, one of the most important violinists in Italy and the world. While he was located in Rome, the student in the class was located with the New World Symphony Orchestra in Miami.
- In January 2007, with a contribution from RENATER (the French NREN), the composers of the two musical works, Henri Dutilleux and Marc-André Dalbavie, attended and interacted in real time in a rehearsal of the New World Symphony Orchestra in Miami from IRCAM[31] (Institut de Recherche et Coordination Acoustique/Musique) in Paris.

The MARCEL project is another example of a network of people in the arts using network technologies and services. MARCEL (Multimedia Art Research Centres and Electronic Laboratories) is defined as *"an umbrella organisation of like-minded artists, scientists and institutions interested in exchange and collaboration operating over a permanent very high bandwidth interactive network dedicated to artistic, educational and cultural experimentation, exchange between art and science and collaboration between art and industry"*[32]. In an interview, Don Foresta, the International Coordinator of the MARCEL Project and Senior Research Fellow at the London School of Economics, explained that MARCEL members use network services for collaboration and even production of events online. They employ Access Grid for videoconferencing, teaching, research and artistic production purposes. MARCEL also works on online archives.

One illustration of use of the network as an integral part of an artwork, mentioned by Don Foresta, is the 'Candle': *"It is a not only a meditation on the poetics of the candle and the flickering light but also becomes a metaphorical meditation on the poetics and possibilities of network art. A Candle situated at Ryerson University, Toronto is placed in front of a speaker. A drummer in England beats a drum and transmits the audio over the Internet to Ryerson University. The audio of the drum is played through the speaker beside the candle. As the drum beats, the candle flickers to its base. The video is transmitted back to England and projected on a wall behind the drummer."* [33].

This trend to introduce network connectivity as part of the creative work was commented on by Georges Albert Kisfaludi[34], a professor at the École Régionale des Beaux Arts de Nantes, France, who

30. *www.internet2.edu/arts/*

31. *www.ircam.fr*

32. *www.mmmarcel.org*

33. *www.rcc.ryerson.ca/synthops/candle.htm*

34. *Author of the SERENATE case study 'French Schools of Art, Communication Networks and RENATER'. See www.terena.org/publications/files/SERENATE-D15.pdf.*

is also a consultant with institutions and services under the supervision of the French Ministry for Culture and Communications. Artists are more and more attracted by multimedia, and this might be due to two phenomena. On the one hand, decreased prices make laptops and broadband Internet access affordable to a wider community. On the other hand, increased capacities of powerful processors and high-bandwidth networks allow for capabilities that used to be supported by custom professional equipment to be handled by off-the-shelf, less costly alternatives.

Some artists create specially for the Internet, leading to virtual artistic galleries and to open spaces where artists can access storage capacities and contact computer engineers who can help them in their creative process. Now artists often use the Web to show and archive their creations. Georges Albert Kisfaludi mentioned the artists Stena and Woody Vasulka, who have archived their works online[35]. The traditional hard-copy catalogues of artworks are thus replaced by the Web. He also explained that a current trend in the arts calls for mixing different artistic disciplines in digital form (music, visual arts, performing arts etc.), quoting the example of the Scopitone festival and artistic platform[36]. This type of platform was also promoted by CIANT (International Centre for Art and New Technologies, Prague) for the e-AGORA[37] project consisting of a virtual platform for performing arts.

The Vooruit Arts Centre[38] in Ghent, Belgium, is an environment dedicated to artists. Vooruit is an international arts centre that presents contemporary performing arts and music, and it is now evolving into an 'arts centre of the future' through a series of projects that integrate network technologies in a creative artistic environment:

- 'Virtual Arts Centre of the Future': a community portal website and an interactive 3D platform;
- 'Wireless Building Automation': wireless networking technology is used not only for providing Internet access throughout the centre, but also for the management of the building; the high-speed Internet access is provided by BELNET, the Belgian NREN.

Finally, these new trends in the arts have also led to pedagogical changes in the student curriculum.

One of the examples given by Georges Albert Kisfaludi, ETREINTES, is a project with the participation of the École Régionale des Beaux Arts de Nantes and the École Régionale des Beaux Arts de Nancy. Both schools are located in France and connected via RENATER. ETREINTES is an imaging mechanism and virtual theatre: two different locations open to public, and actors/dancers on both locations interact with the virtual representation of the remote actors/dancers.

The developments presented in this section demonstrate the important impact of ICT, including network services and technologies, on modern research practices in AHSS.

A report[39] written by Angela Piccini (Research Councils Academic Fellow, Department of Drama: Theatre, Film, Television, University of Bristol) provided interesting input to the current study. As part of the University of Bristol research theme Performativity | Place | Space, several workshops on 'Locating Grid Technologies' were held between June and October 2006 in order to investigate *"the potential of Grid technologies to produce new understandings of space and time for distributed, creative research practices"* .

Angela Piccini wrote: *"The project brought together mixed-mode researchers from the UK, US and Japan*

35. *www.vasulka.org*
36. *www.scopitone.org*
37. *www.ciant.cz/node.pix.php?nid=1&nlang=1&npix=1&nclr=black and www.e-agora.info*
38. *www.vooruit.be*
39. *www.ahessc.ac.uk/files/active/0/PPS-report.pdf*

to generate, analyse and re-use audio-visual documents of distributed practice-led research. In doing so, the project explored fragmentations of space and time in networked environments by: using Access Grid as a telematic performance environment and as a dissemination tool for other performance forms; using a range of software interfaces within Access Grid events to record, annotate and retrieve the Access Grid meetings; using a Semantic Web database to query that audio-visual archive in such a way as to facilitate its re-use in performance, in programmed installation environments and in virtual working environments.". In terms of network-related technologies, the report highlighted the need to lower both sound and visual latencies and to understand device and user mobility issues better. It also said: *"The complexity of negotiating institutional firewalls, software compatibility and interoperability, unstable beta versions and developing new, leading-edge applications tested project collaborators' limits.".*

Issues related to latency, which arise when using network communications as an integral part in an artwork, are of high concern in the performing arts. More technical details of this problem will be considered in Section 6.3. Specialists from IRCAM stressed that, in their particular field of music, network latency, jitter and data compression are considered unacceptable. Many of the artworks in IRCAM's collection of about 450 items are not in stereo, but in multipoint sound formats dedicated to professional equipment. Their SoundJack experiment[40] studied the distances over which artists located in different locations may feasibly play a piece together. Provided that all other elements of the transmission path were carefully engineered to minimise any additional latencies, in the end the delay due to signal propagation inside optical fibres is imposing an upper limit on the distances between remote performance venues.

6.2.2 Virtual environments

Virtual environments form a new category of network use. One example of a virtual environment in the social sciences and humanities is the Virtual Montmartre project of the Université Paris-Sorbonne Paris IV, 'Cultures Anglophones et Technologies de l'Information'. The project developed *"content related to artistic, historic, geographical, musical and literary activities occurring in Montmartre during the early part of the 20th century"*[41].

As Marie-Madeleine Martinet, one of the scholars involved in the Virtual Montmartre project, already mentioned in her contribution[42] to the SERENATE study, network technologies and services are used in the humanities for three purposes:

- authoring and delivering multimedia resources;
- accessing databases;
- human networking and collaborating in projects (distance education, international co-operation).

An additional example of a virtual environment was given during the Internet2 'International Forum on Digital Humanities, Digital Libraries and Virtual Museums: videoconferencing and beyond' in a presentation made by the Institute of Technologies Applied to the Cultural Heritage of CNR (ITABC) in Rome. Their Virtual Heritage Lab *"is a digital lab focused on digital projects in archaeology and in the cultural heritage. In the VHLab Desktop Virtual Reality applications in intra-site contexts (monuments, archaeological excavations) and in inter-sites contexts (archaeological landscapes) are developed."*[43]. Sofia Pescarin, archaeologist, explained that the researchers have developed open-source Web plug-ins based on the OpenSceneGraph library for real-time navigation in a virtual-reality

40. *www.alainrenaud.net/docs/NIME_06_SARC_positionpaper.pdf*
41. *www.montmartre-virt.paris4.sorbonne.fr*
42. *SERENATE Users Workshop, Montpellier, 17-19 January 2003. See www.serenate.org/seuw-presentations.html.*
43. *http://www.itabc.cnr.it/VHLab/HomeVHL.htm*

landscape[44]. They have also worked on plug-ins for exporting three-dimensional virtual-environment data for Web publication. In addition, they have recently developed a Web-Community-like application (a Multi User Domain) for a museum.

6.2.3 Databases

Humanities and social sciences can be regarded as cumulative sciences: researchers have to examine large quantities of existing materials on a topic. For this reason, fast and secure access to databases is crucial for these disciplines.

According to Françoise Thibault, expert in the humanities with the French Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche, scholars in the humanities need access to digital information for several purposes:

- access to raw data: researchers make materials available online (such as pictures, data or even - in the case of ethnologists - interviews) that can help other researchers in their work and studies;
- access to public databases;
- access to digitised knowledge (i.e., articles) produced by other researchers (see, for example, the PERSEE initiative mentioned below);
- access to educational information, like courses or movies (see, for example, the CANAL-U initiative mentioned below);
- access to scientific information and popularised scientific information, via dedicated Web portals.

The PERSEE initiative[45] consists of a Web portal for scientific journals in the social sciences and humanities. A large number of periodicals and journals were digitised and made available for online distribution. For example, a search for the journal 'Annales' reveals the content *"from the journal's founding in 1929 under the original title, Annales d'histoire économique et sociale (Annals of Economic and Social History), to its current name, Annales, Histoire, Sciences Sociales (Annals. History and Social Science), this is the collection of history journals par excellence".* In terms of infrastructure, the servers are located at CINES (National Computer Centre for Higher Education) in Montpellier, and connected at high bandwidth to RENATER.

The CANAL-U initiative[46] created Web television for the French institutions of higher education, providing large audiovisual programmes with educational documents to students, teachers and the public at large. Among the twelve current channels, CANAL GEO is dedicated to geography, CANAL SOCIO to sociology and anthropology and VO to foreign languages. The CANAL-U server is also hosted at CINES.

At this point, it is also important to mention the European initiatives related to data archives in these fields. For example, CESSDA (Council of European Social Science Data Archives) federates data archives for social sciences in Europe.

DARIAH[47] (Digital Research Infrastructure for the Arts and Humanities) was one of projects listed in the ESFRI Roadmap document[48]. According to the project website, *"Research practice in the arts and humanities is about criticism and meaning, interpretation and re-interpretation, and about extracting meaning from often incomplete and fuzzy data. It requires researchers to seek out and track down a wide range of primary and secondary sources, to organise and structure these, and to analyse and interpret them,*

44. *www.appia.itabc.cnr.it*
45. *www.persee.fr*
46. *www.canalu.fr*
47. *www.dariah.eu*
48. *http://cordis.europa.eu/esfri/roadmap.htm*

and to publish the results. In the era of pervasive broadband connectivity the way in which these processes are undertaken is changing, and in some cases, the processes themselves are changing. Increasingly, research practitioners are using the power of the web, new tools, and the range of digital information that is available to them, to create their own personal network spaces, to publish on-line highly interactive themed collections of research information and knowledge, and to visualise and reconceptualise their interpretations and analysis. New forms of collaboration are also emerging as the tools available encourage and enable 'web-working' across the globe. Meeting the challenges created by these changing research practices requires a new kind of Research Infrastructure that can respond easily and seamlessly.".

Other aspects related to online AHSS databases were outlined by the LAIRAH[49] (Log Analysis of Digital Resources in the Arts and Humanities) project at the University College London's School of Library Archive and Information Studies. The research objectives of the project were *"to determine the scale of the use of digital resources in the humanities, using deep log analysis of the Humbul, Artifact and AHDS portal sites; to determine whether resources that are used share any common characteristics; to highlight areas of good practice, and aspects of project design that might be improved to aid greater use and sustainability."*

The project focused on the need to have information not only archived, but also easily accessible and interrogated. The report stated that *"libraries, archives and research centres have not been replaced by digital resources"* and *"digital resources ought not to be seen as an alternative to libraries and archives".*

6.3 Use of the National Research and Education Network

The generic view on using an NREN connection for daily research and teaching duties was perhaps best expressed by Dr. Melissa Terras, a lecturer at the University College London: *"It's free! It's there! It's fast! It's no problems! It's provided by the uni!".* We believe that this view is representative not only for the large category of the 'other' users who use the Internet for mundane day-to-day tasks such as collaboration through email and messaging, accessing other people's scholarly works over the Web and having an online presence on the website of the university department, but also for the category of users who have more demanding applications. Researchers and academics in the fields of arts, humanities and social sciences are increasingly integrating state-of-the-art Internet-related technologies into their projects. This was also made clear in the responses that we received to our questionnaire.

As we cited Dr. Melissa Terras above, it would be worthwhile mentioning that her research group is involved in several collaborative activities, using applications such as Access Grid for collaboration, virtual environments for archaeology, large databases and computational Grids for analysing more than 150 years of historical data records.

The remaining part of this section is organised as follows. Several categories of advanced applications in the arts, humanities and social sciences are clustered based on technical requirements. Each category of requirements is analysed in detail in a separate subsection.

6.3.1 Real-time collaboration technologies

The category of real-time collaboration technologies consists of applications that allow people to work together, in real-time, through the Internet. This includes voice- and videoconferencing, instant

49. *www.ucl.ac.uk/slais/research/circah/lairah/*

messaging and virtual-reality environments. This is in contrast to email, which is the best example of non-real time collaboration technology. Responses to our questionnaire indicated that both voice- and videoconferencing are used routinely by people in the AHSS for collaboration, mainly in the framework of trans-institutional and international projects. This section gives an overview of the network-related requirements of applications in the real-time collaboration area.

Standard videoconferencing equipment deployed in universities is based on H.323 and related standards. The H.261 and H.264 video codecs and the G.711, G.723, G.726 and G.729 voice codecs are widely supported by multi-vendor equipment. The bandwidth requirements for these codecs are well-known, since they are specified in the respective standards. The influence of network Quality of Service on the quality of the communication perceived by the user was the subject of ITU-T Recommendations P.862 (voice-related objective performance measurements) and J.144. Also a deliverable[50] of the EuroNGI network of excellence presented several studies on this problem. It is generally accepted that the jitter values must be lower than 50 ms; otherwise the perceived quality of the conversation is affected. Depending on the features supported by the hardware deployed at the participants' locations, collaborative application and desktop sharing through standards such as T.120 or H.239 may also be available, in addition to voice and video.

Access Grid is a virtual environment for collaboration, which integrates application sharing with multiple cameras providing multiple viewpoints per participant. It was first developed at Argonne National Laboratory in the United States. An open-source implementation of the toolkit is available on the site of the laboratory[51].

The CIANT centre[52] (which is connected to CESNET) developed the use of Access Grid for its Polylogues project: series of videoconferences through the Access Grid teleconference platform in order to stimulate interdisciplinary exchange of ideas.

In Europe, JANET(UK) set up a special Access Grid support team[53] at the University of Manchester. According to them, the most used codecs are H.261 for video and G.711 or Linear16 mono for the audio. The use of these codecs has implications for the overall quality of the videoconference. Casual collaboration is well served by the use of these codecs. However, the need for improving the quality of the sound in this environment is clearly shown in the Piccini report[54] mentioned in Section 6.2.1. A significant increase in the sound quality available through the Access Grid framework would be required for the environment to be used in the professional artistic community.

A different type of real-time collaboration or educational interaction is taking place in virtual-world environments such as ActiveWorlds (AWEDU), Second Life and There.com. A virtual world allows digital representations of the participants (avatars), which meet in a three-dimensional computer-generated environment. Standard features included in modern virtual worlds consist of graphics, text chat functionality and the possibility for the avatars to move in all three dimensions. Second Life trialled a voice-based interaction based on the Siren14 codec (a proprietary implementation of the G.722.1 specification) in March 2007. Several universities announced a presence in Second Life and the intention to offer classes to their students, including INSEAD, a leading French business school, and Vrije Universiteit Amsterdam. Without voice, one connection to Second Life may require as much as 400 kb/s of bandwidth, according to the 'Campus:Second Life'

50. *http://eurongi.enst.fr/archive/127/JRA612.pdf*

51. *www-unix.mcs.anl.gov/fl/research/accessgrid/index.html*

52. *www.ciant.cz*

53. *www.ja.net/services/video/agsc/section-1/*

54. *www.ahessc.ac.uk/files/active/0/PPS-report.pdf* program[55]. As much as 48 kb/s would be required, per connection, for the voice functionality. As opposed to videoconferencing, where people in the same physical room may use one connection for participating in a meeting, virtual worlds require each participant to have his/her own connection. The widespread use of virtual worlds as a collaboration technique would thus generate a significant increase in the amount of bandwidth usage. It should also be noted that good quality of service needs to be maintained; otherwise the overall interaction experience and voice quality would suffer.

Here it is important to note that both the high bandwidth and the quality of service offered by NRENs are real assets to develop real-time collaborations.

6.3.2 Live performances - music and dance

Live performances of classical music or collaborative dance projects involving streaming over IP networks are in the process of transitioning from one-off events to regular, scheduled events. Projects such as Opera Oberta (which will be discussed later in this section) are representative for this trend. Other types of live streaming, such as the broadcast of TV programmes using peer-to-peer technology in the same way as Inuk[56] or Joost[57], may be of interest to end-users in the arts and humanities (as in any other domain, for that matter), but are not covered by the present study. However, it should be noted that insomuch as peer-to-peer technologies will prove successful as a medium for live streaming, it should be expected that they will also be used for AHSS projects involving live performances. This section examines the network-related aspects of providing high-quality video streaming in the NREN context.

Opera Oberta[58] is a partnership between Gran Teatre del Liceu, Barcelona and several universities, national research and education networks, regional networks, telecommunications carriers and SMEs to offer a university course on opera. The 2006-2007 edition of the course included live streaming five of the performances at the Gran Teatre del Liceu to several locations in Spain, France and Chile. The requirements on the network infrastructure were quite demanding:

- support for multicast-enabled MPEG-2 video streaming at a bandwidth of 8-10 Mb/s;
- Dolby Digital 5.1 surround sound at 640 kb/s during the opera;
- four streams encoded with the MPEG1-layer III standard, at 250 kb/s each, during the seminar that preceded the opera.

Solutions to transmit the MPEG-2 video on IPv4 and IPv6 networks were trialled and employed during the performances. The live streams were encrypted in order to comply with legal requirements for maintaining the broadcast rights. The encryption was performed on hardware equipment that was installed before the edge of the transmission network. In this respect, this application was similar to an encrypted TV broadcast, where the audience receives the content and may have an out-of-band channel for interacting with the production team in charge of the event.

A more demanding scenario[59], involving a distributed performance, was showcased during an experiment between IRCAM in Paris and the New Symphony Orchestra in Miami, which was mentioned in Section 6.2.1. The demonstration involved real-time interaction between the orchestra located in Florida and the two composers of the music, located in Paris. The experiment used the

55. *www.simteach.com/wiki/index.php?title=Campus:Second_Life*
56. *www.inuknetworks.com*
57. *www.joost.com*
58. *http://opera-oberta.liceubarcelona.com/altresNav.html*
59. *www.renater.fr/IMG/pdf/Dossier_de_presse_Ircam_RENATER.pdf*

Digital Video Transport System (DVTS)[60] for streaming high-quality video and audio between the two locations. The DVTS transmission required a bandwidth of 30 Mb/s for supporting a full PAL resolution, 30 frames per second video signal without compression. This type of interaction between professional artists imposes strict conditions on the overall system architecture. The total latency involved in transmitting data throughout the system must be minimal. The NREN was instrumental for this type of experiment, as it allowed for a high-speed high-quality connection between the two participants in the event. The choice of DVTS as the streaming technology contributed to minimising the overall latency experienced by the participants. The absence of video compression in the DVTS stream eliminated a step that could have increased the latency by tens or hundreds of milliseconds, depending on the hardware implementation of the encoders and decoders.

A dance performance of the Nulhui Dance Company in Seoul was streamed with high-definition video to the theatre of Mercat de les Flors in Barcelona over a combination of lightpaths[61] provided by several research networks (KREONet2, GLORIAD, CAnet4, GÉANT2, RedIRIS, CESCA). The total throughput of this uncompressed video transmission was around 860 Mb/s of sustained multicast traffic.

Live streaming of concerts and performances were also mentioned, among other examples, as a major component in the 'Virtual Arts Centre of the Future' project at Vooruit in Ghent, Belgium. Projects like CineGrid[62] involve participants from European universities and research networks. Efficient streaming of high-definition video over photonic networks is one of the major areas addressed by CineGrid. For example, a demonstration performed by a team from Purdue University during the SC06 conference[63] produced almost 10 Gb/s of uncompressed high-definition video stream. According to the team, the data rate could be reduced to around 1 Gb/s if compression algorithms were to be used. However, as noted above, compression technology might not be adequate for use in all scenarios.

These experiments demonstrate that multi-channel sound and high-definition video streaming are of paramount importance to a new wave of artistic performances to be streamed over research and education networks. The bandwidth and jitter requirements vary, depending on the type of codecs used and the actual application. Another aspect, of particular importance when musicians or dancers participate in the performance from different locations, is the issue of the overall latency involved in the transmission.

The time needed for propagating signals on optical fibre cannot be improved, so a certain component of the latency can only be influenced by carefully designing the network topology between the locations. Frameworks that use lightpath or bandwidth-on-demand provisioning allow for this type of design and are in operation in many NRENs and on GÉANT2. However, video and sound encoding and compression may take in the order of tens or hundreds of milliseconds, even when the respective algorithms are implemented directly in hardware. While waiting for more efficient hardware to become available on the market, the best solution for minimising the latency in the case of live streaming with distributed performers would be to eliminate the compression step. This has the effect of increasing the bandwidth requirements on the network by an order of magnitude. The examples presented in this section showed that throughputs of 1 Gb/s and even 10 Gb/s are well within reach of current streaming equipment that can be attached to the network.

60. *www.dvts.jp/en/dvts.html*
61. *www.i2cat.net/i2cat/ImgsPortal/dancingq_demoplan.pdf*
62. *www.cinegrid.org*
63. *http://sc06.supercomputing.org*

6.3.3 Libraries and digital repositories; copyright issues

As noted by the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities[64] in 2003, *"The Internet has fundamentally changed the practical and economic realities of distributing scientific knowledge and cultural heritage. For the first time ever, the Internet now offers the chance to constitute a global and interactive representation of human knowledge, including cultural heritage and the guarantee of worldwide access."*. Issues like open access to information, unrestricted distribution, interoperability and long-term archiving are the pillars of the Berlin Declaration. Conferences in support of the Declaration have been organised annually since 2003. Almost 250 organisations involved in the production and use of scholarly publications have signed the Declaration. International initiatives, such as Open Archives[65], develop and promote the adoption of standards for interoperability of digital repositories.

Works covered by the Berlin Declaration include *"original scientific research results, raw data and metadata, source materials, digital representations of pictorial and graphical materials and scholarly multimedia material"*. Making the works available under the Open Access framework does not mean that the authors lose their legal rights on the works. Instead, the authors grant *"all users a free, irrevocable, worldwide, right of access to, and a license to copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship"*. The issues of respecting copyright remain of great importance to the academic and research communities, although it is also important to provide equal opportunities for accessing the information to all members of the community.

Our survey found that the approach towards long-term archiving and digital repositories may present fundamental differences between the points of view in the field of arts and those in the humanities and social sciences. In this context, Georges-Albert Kisfaludi mentioned the work of Fred Forest[66], for whom a work of digital art is an ephemeral creation and what needs to be recorded are the reactions of the public in the presence of the work. Therefore, archiving digital artwork of this kind would make no sense for the artist.

In various fields of the humanities, digital repositories for scholarly data are a topical subject of discussion. The ESFRI roadmap[67] identified research infrastructure project plans that address the needs of the humanities and social sciences. All of them have at least one component related to digital repositories or digital archives. The six are:

- Council of European Social Science Data Archives (CESSDA);
- Common Language Resources and Technology Infrastructure (CLARIN);
- Digital Research Infrastructure for the Arts and Humanities (DARIAH);
- European Resource Observatory for the Humanities and the Social (EROHS);
- The European Social Survey (ESS);
- Survey of Health, Ageing and Retirement in Europe (SHARE).

One of the requirements for this new category of eInfrastructures is that they will be powered by a new generation of search engines (in the context of the Semantic Web), better adapted to the needs and operational habits of scholars in the humanities and social sciences. New ranking systems and humanities-friendly user interfaces will be integral parts of the new repositories. Although these requirements have no direct influence on the services to be provided by NRENs, their fulfilment has

64. *http://oa.mpg.de/openaccess-berlin/berlindeclaration.html*
65. *www.openarchives.org*
66. *www.fredforest.com*
67. *http://cordis.europa.eu/esfri/roadmap.htm*

the potential to change the patterns of Internet activity for an entire field. Therefore, the volume of IP traffic could be increased potentially by a significant amount. Details on the technical requirements for some of these eInfrastructures will be presented in other sections of this report.

Most of the AHSS projects identified by the ESFRI roadmap would federate national and/or institutional digital repositories. Such repositories are based on large databases storing various categories of content as mentioned in the Berlin Open Access Declaration. Efficient access to such resources could be made available only through an integrated metadata domain to allow users to compose their own set of resources through either browsing or searching a domain-wide catalogue. When these functions, together with the proper authentication and authorisation, are provided by Grid-enabled middleware, the domain could be referred to as a Data or Storage Grid.

The ReACH[68] (Researching e-Science Analysis of Census Holdings) workshops, led by University College London, investigated the applicability of Grid computing techniques to a large dataset, made of the entire historical census records in Wales and England from 1841. Anecdotic references estimate the amount of data to be analysed in the order of O(100) TBytes. A large Storage Grid infrastructure will need to be set up for making this data available to researchers. Taking into account the computational Grid required for actually running the algorithms for the data analysis, ReACH was one of the most ambitious projects in the humanities field that we encountered during our survey. To the best of our knowledge, a final design of the infrastructure supporting ReACH was not made available in time for our study. We could only speculate that, depending on the physical distribution of the repository and the nature of the data-processing algorithms, there is a high potential for a significant amount of network traffic to be generated by the project.

The storage requirements for the federated repository of the TextGrid project[69] will be also in the range of O(100) TBytes. The project developed a Service Oriented Architecture (SOA) interface for accessing data in a set of federated repositories. Four large repositories were federated through the DAM-LR project[70]. The project managers mentioned plans to continue and extend the work of this project in the context of the CLARIN initiative mentioned in the ESFRI roadmap.

A significant part of the work in federating large repositories is related to properly authenticating and authorising users. These issues are covered in Section 6.3.4.

6.3.4 Authentication and Authorisation Infrastructures and trust

The need for providing Authentication and Authorisation Infrastructures (AAIs) in the context of federated access to resources has been acknowledged by virtually all the projects that were contacted for the survey. Whether the federated access is granted to resources that belong to an institution or a group of institutions, or to commercially available material that is purchased by an institution or project, AAI is paramount.

According to the DAM-LR and TextGrid projects, there are many researchers operating autonomously in the fields of humanities and social sciences[71]. However, the standard authorisation mechanisms that are broadly deployed require institutionally supplied attributes to identify individuals. Shibboleth, the mechanism already adopted widely in the digital-library domain, was found to provide all the required flexibility for handling these specific requirements.

68. *www.ucl.ac.uk/slais/research/reach/*

69. *www.textgrid.de*

70. *www.mpi.nl/DAM-LR/*

71. *www.lat-mpi.eu/papers/papers-2006/dam-lr-final3.pdf*

In the European research and education community, the eduroam® service allows users of the participating institutes to login on the network at the premises of all the other participating institutes[72]. eduGAIN is an authentication and authorisation framework that is being developed in the GN2 project to provide an interoperable AAI for seamless sharing of eScience resources. The work started in TERENA's task forces TF-EMC2 and TF-Mobility is advancing in this way towards a Single Sign-On system that will be provided as a service by the NRENs to the European research and education community. Future developments will have to take into account the requirements of the humanities and social sciences:

- the possibility to include autonomous researchers (e.g., users not necessarily attached to an institution);
- use of Shibboleth as one of the AA mechanisms supported by the confederation.

A secure federated environment can only be based on the existence of a trusted computing infrastructure. The basic components of such an infrastructure are trusted servers and services. In this context, 'trusted' is defined as meaning that each component of the infrastructure is duly authenticated. The NREN community has approached the problem of trust through the facilities offered by the TERENA Academic CA Repository (TACAR)[73] and TERENA's Server Certificate Service.

TACAR was set up as an online repository containing root-CA certificates (trust anchors) from NRENs and national academic public-key infrastructures. The Server Certificate Service allows the participating NRENs to issue SSL server certificates, with a well-known root CA, for themselves and their user communities. We refer to a CA as being 'well-known' when its own certificate is available in the binary distribution of the most popular Web browsers. The possibility of tracing a certificate down to a well-known root eliminated the annoying pop-up window that appeared in browsers when a secured webpage was accessed and the certificate was issued by an unknown authority. In a more general context, the process of issuing certificates in such an environment creates the premises for trust. These certificates can also be used in other scenarios, such as Grid computing. The DAM-LR project mentioned the intent of their collaborators to become a Registration Authority recognised by TACAR, and to request certificates for the servers of the DAM-LR infrastructure.

6.3.5 Peer-to-peer technologies

According to Yochai Benkler[74], Professor of Law at the Yale Law School, *"(…) we are seeing (…) the broad and deep emergence of a new, third mode of production in the digitally networked environment. I call this mode 'commons-based peer-production', to distinguish it from the property- and contract-based models of firms and markets. Its central characteristic is that groups of individuals successfully collaborate on large-scale projects following a diverse cluster of motivational drives and social signals, rather than either market prices or managerial commands."*. While technologists merely provide the tools to empower the community, scholars in the AHSS are at the heart of this phenomenon. They are the creators of the content and further the understanding of philosophical and sociological explanations of peer-to-peer. Workshops such as the Re:activism[75] workshop organised by the Budapest University of Technology and Economics, and the Art|Net|Work[76] seminar hosted by Aarhus University were expressions of the wide importance of this field for scholars in the humanities.

® *eduroam is a registered trade mark of TERENA.*

72. *www.eduroam.org*

73. *www.tacar.org*

74. *Yochai Benkler, Coase's Penguin, or, Linux and The Nature of the Firm, The Yale Law Journal, vol. 112. See www.benkler.org/CoasesPenguin.html*

75. *http://mokk.bme.hu/centre/conferences/reactivism/*

76. *www.interfacekultur.au.dk/da/nyt/artnetwork/*

From the technological point of view, the peer-to-peer field could be categorised in two distinct groups: server-centric platforms, such as YouTube, MySpace, Facebook, Wikipedia, Flickr etc., and client-centric platforms for content distribution, such as BitTorrent, Kazaa, Napster, Skype etc. In a survey carried out by the SPIRE[77] project in the United Kingdom, the level of penetration of peer-to-peer technologies in general was found to be quite high.

The debate on copyright for some of the material distributed through peer-to-peer platforms is still ongoing all over the world. It is common knowledge that a large amount of copyrighted work is shared through peer-to-peer platforms without the knowledge and approval of the copyright holders. The legislative aspects are complicated by the inherent trans-national aspect of peer-to-peer usage. Fair or acceptable use policies are specified by the NRENs and the commercial Internet Service Providers, as well as by the sites and logical networks hosting the content. It is very difficult to enforce these policies in the absence of technological methods to distinguish copyrighted material distributed without the agreement of the owner from rightfully distributed content. Although various efforts were made to address this problem, to date none of them has really provided a generic, faultless solution.

Efforts to spread the use of peer-to-peer technologies beyond video-distribution and social-networking sites are underway in the research community. In this respect, we could mention the work in the DELOS[78] network of excellence on digital libraries. *"MINERVA is a P2P Web search engine prototype that envisions a collaboration of autonomous peers. Peers are expected to run a local search functionality on a local index, e.g., created by the integrated focused crawler Bingo!."*[79]. A prototype of a peer-to-peer digital library *"(…) supports data management in a dynamic network of autonomously managed digital library nodes (...) Each DL node chooses itself when to join and/or leave the library network. The system can gracefully adapt to these joins and departures without any global structural knowledge."*[80].

6.3.6 Online surveys

Statistical surveys are part of the groundwork to be performed in social sciences and certain areas of economics, e.g., marketing. Surveys are tools that collect quantitative information about items in a population[81]. The advent of Web technologies brought a new tool in the arsenal of social-science researchers, the online survey, as a complement or replacement of the paper version. In terms of technical infrastructure, the generic requirements for online surveys could easily be fulfilled with a standard Internet connection, a Web server machine in a standard configuration and the software to present the questionnaire, collect the responses and analyse the results. Of course, the actual sizing of the infrastructure depends on the particular problem to be addressed and the methodology for carrying out the survey.

The European Social Survey (ESS)[82] is an academically driven social-survey infrastructure designed to chart and explain the interaction between Europe's changing institutions and the attitudes, beliefs and behaviour patterns of its diverse populations. The Survey of Health, Ageing and Retirement in Europe (SHARE)[83] is a multidisciplinary and cross-national database of micro data on health, socio-economic status and social and family networks of individuals aged 50 or over. Both initiatives

77. *http://spire.conted.ox.ac.uk/trac_images/spire/SPIRESurvey.pdf*
78. *www.delos.info*
79. *www.delos.info/index.php?option=com_content&task=view&id=557&Itemid=298*
80. *www.delos.info/index.php?option=com_content&task=view&id=550&Itemid=291*
81. *http://en.wikipedia.org/wiki/Statistical_survey*
82. *www.europeansocialsurvey.org*
83. *www.share-project.org*

were mentioned in the ESFRI roadmap. From the respondents to our questionnaire, a scholar from University of Ghent and Ekkehard Mochmann from GESIS (German Social Science Infrastructure Services) mentioned they were involved in social-sciences projects that conducted online surveys.

6.4 Conclusion and future use

Based on our interactions with artists, researchers and academics involved in the fields of arts, humanities and social sciences, we can conclude that these domains have intensified their use of Internet technologies compared to the interval covered in the SERENATE reports. The diversity of the technologies employed and the persistence of the infrastructures signal an important paradigm shift towards online collaborations. As yet, the work in this community does not show any strong links to the Grid. However, this is expected to change. Currently, the use of Grid technology is limited to AA middleware. Projects such as TextGrid open the way to a wider adoption of these technologies in AHSS. Although quite radical, this conclusion is necessarily logical taking into account the global evolution of society and technology. It is also in line with responses to our short questionnaire.

There is an increase in the number of multi-disciplinary scientific projects that involve people in the humanities and social sciences working together with researchers from computer-science and engineering departments. At the same time, computer scientists, software developers and engineers are employed to support the work of projects in the humanities and social sciences. Concurrently, the number of scholars in the humanities and social sciences with knowledge of modern computing and network technologies is growing. Several documents that were made available to us acknowledged the need to provide specific training in these technologies to scholars. Centres dedicated to promoting and supporting the use of eScience in the arts, humanities and social sciences have been established in several European countries. The Arts and Humanities e-Science Support Centre (AHeSSC)[84] hosted at the King's College London and the German Social Science Infrastructure Services (GESIS)[85] are just two examples.

If we were to extrapolate the technical requirements for services provided by NREN infrastructures, we believe that five major areas can be identified:
- bandwidth and quality of service;
- high-quality collaboration services;
- authentication and authorisation infrastructures;
- support and training for using new Internet technologies as they arrive;
- raised awareness in the AHSS community of how new services developed by the NRENs could transform their work, and also raised awareness in the NREN community of the problems that are being approached within AHSS.

As explained in Section 6.3, NRENs provide both infrastructure and services needed by the AHSS community; we can say they serve the community very well. Therefore we are confident that we will see an increase in network use by the AHSS in the coming years.

NRENs have to be aware that this community of users is very demanding, both in terms of infrastructure and services, and they may have to dedicate special outreach and training to them in the future.

84. *www.ahessc.ac.uk*
85. *www.gesis.org/en/index.htm*

7. Report on the healthcare sector[86]

7.1 Introduction

In Europe, the ICT infrastructure of research and education institutions has been leading the way in both technology and capacity. Therefore, it is natural to bring the developments of proven value to the benefit of other sectors with similar characteristics that have demands for the same type of infrastructure and services.

Health research and the health sector in general are experiencing a rapidly increasing need for high transmission bandwidth for high-resolution images and video streaming used for remote diagnostics, monitoring and the teaching of surgical techniques. It is believed that the know-how, experiences and infrastructure of the National Research and Education Networking organisations (NRENs) could benefit the sector, in terms of both economy and capacity.

This chapter reports on a study on healthcare and health research that was carried out as part of the EARNEST foresight study. The study is based on literature and Web searches for eighteen countries as well as discussions with a group of thirty people, including some with extensive experience in 'big pharma', regional health, health research and the NRENs. The study was carried out between November 2006 and May 2007.

The report was edited by Christina E. Wanscher from MedCom in Denmark together with Henrik Søndergaard and Martin Bech, both from UNI•C in Denmark.

The editors wish to thank the many contributors, some of whom are mentioned in the sections below. Furthermore, they owe special thanks Niels Rossing (MedCom) and Tor Bloch for their contributions.

The chapter starts with an introduction to eHealth, focussing on the context for network development and the differences between the sector and other areas of society. One of the key characteristics of healthcare is the very strong emphasis on secure and reliable data-transfer between the stakeholders, in order to protect the sensitive personal data that is often involved. The following section presents a short overview of various European health data networks, classified as national, regional and local organisational structures. Finally, in the last sections, suggestions are made as to how NRENs, based on their strengths and experiences, can potentially participate in the further development of national health data networks.

7.2 From information silos to connected eHealth

Healthcare has developed and deployed IT systems and ICT services in the last 40 years of the 20th century. Examples of how the technology has been used can be found in administrative applications, digitised diagnostic equipment and electronic health records. In an attempt to improve information flow and knowledge, many healthcare providers have invested in technologies such as online order entry, electronic medical records, and picture archiving and communications systems (PACS). These

86. *Authors: Christina Wanscher (MedCom), Henrik Søndergaard (UNI•C) and Martin Bech (UNI•C)* applications usually support care within an organisational silo - such as a hospital - rather than being available across multiple organisations.

The typical hospital has more than 300 applications in use on any given day, and many hospitals maintain separate networks for various functions and departments, adding cost and complexity[87]. Even between health entities in a region or municipality, digital communication or interoperability of systems are rarely facilitated between different institutions like university hospitals, general hospitals, pharmacies, primary clinics and the social sector.

The underlying potential to improve effectiveness and efficiency has been recognised by governments worldwide and national eHealth strategies aimed at developing health information infrastructures and 'infostructures' are emerging across North America, Australia, Europe and elsewhere. These are united by a vision to improve the safety, quality and efficiency of patient care by enabling access to electronic health records and by supporting clinical practice, service management, research and policy through availability of appropriate digital information. These strategies emphasise the importance of establishing standards and policies for ensuring interoperability and data security, and many incorporate a commitment to facilitate consumer empowerment and patient self-care through provision of electronic information and/or telemedicine facilities[88].

Despite the clear interest in, and apparent marketability of, eHealth, the term has been variously used as a synonym for health informatics or telematics, telemedicine, consumer health informatics and e-business, as well as more specific technological applications, but no consensus exists on its conceptual scope. One of the most quoted definitions is that of Eysenbach: *"eHealth is an emerging field of medical informatics, referring to the organisation and delivery of health services and information using the Internet and related technologies. In a broader sense, the term characterises not only a technical development, but also a new way of working, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology."*[89].

The existence of these basic challenges to define the concepts related to the delivery of health services and exchanging information using Internet-based network technologies makes it difficult for NRENs to position themselves to offer value-added services to the sector.

7.2.1 Providing network services to the health sector is different

The use of ICT in the health sector is driven from the applications. These are typically developed to address very specific processes, and in most cases the sector has not gone through the major organisational changes that other sectors like finance and production have had to go through to benefit fully from the technological advances in ICT in terms of quality of service and cost. The large number of applications and the variety of data formats make interoperability very difficult and expensive to achieve. There is a lack of globally accepted standards for data exchange, although organisations like HL7[90] are working on these aspects. Scaling of applications that have been successful in a limited domain (geographical or pathological) to a national level is often very difficult for those reasons. In some ways, it is more difficult in this sector than in many

87. *Cisco Systems, Making Connected Health a Reality, 2006*

88. *Pagliardi et al., What is eHealth: A scoping exercise to map the field, Journal of Medical Internet Research, 2005*

89. *G. Eysenbach, What is eHealth?, Journal of Medical Internet Research, 2001*

90. *Health Level Seven, Inc. (HL7), is an all-volunteer, not-for-profit organisation involved in development of international healthcare standards. 'HL7' is also used to refer to some of the specific standards created by the organisation. See http://en.wikipedia.org/wiki/Health_Level_7.*

other economic sectors to make process changes that would allow the sector to benefit more fully from technological advances in ICT; that is due to the specificities of the sector and its great sensitivity.

However, the health sector is experiencing a rapidly growing need for exchanging both data and connections between its large number of applications, while at the same time privacy and security of the data can under no circumstances be compromised. In healthcare organisations and especially those that are collaborating with research institutions, everyone would like to exchange data, and healthcare professionals are normally involved in both research and general healthcare. Every small part of the health system has its own firewall, security-administration and access-control mechanisms. Every connection to or from such entities requires approval, configuration, documentation and subsequently auditing to ensure that privacy and security of the sensitive personal data involved is respected.

In spite of these constraints, the connected medical research and healthcare environment has benefited enormously from the advent of the Internet and broadband. Thus in 2004, a communication from the European Commission[91] stated *"Broadband has also led to revolutionary developments in the medical field. It enables collaboration among different organisations and health professionals, and it provides the necessary infrastructure for bandwidth-intensive applications such as telemedicine (for example tele-consultations, telemonitoring, and telecare, either at home or in hospital)."*.

In this context, 'broadband' refers to a wide range of technologies that have been developed to support the delivery of innovative interactive services, equipped with an always-on functionality. The same document argues that *"to realise the benefits of broadband-enabled services, public administrations, schools and health centres need to be connected. The aggregation of public-sector demand increases certainty of expected revenues facilitating investment. It is particularly important in under-served areas accompanying supply-side initiatives to foster deployment."* .

7.2.2 Funding from the European Union

The European Union has been supporting health informatics or telematics for nearly twenty years[92].

In the *e*Europe 2005 plan of the European Union, the term eHealth was introduced together with eGovernment, eBusiness and eLearning with an overall purpose of providing Europe with secure online services, applications and content over an interoperable broadband infrastructure. The European Commission is further stimulating this development by its i2010 plan[93] and the establishment of working groups and stakeholder groups on eHealth.

The European Commission has proposed a new strategic framework, i2010 - European Information Society 2010, laying out broad policy orientations. The framework promotes an open and competitive digital economy and emphasises ICT as a driver for inclusion and quality-of-life. The first objective is formulated as *"a Single European Information Space offering affordable and secure high-bandwidth communications, rich and diverse content and digital services"*. Four challenges for obtaining digital convergence are listed: speed, rich content, interoperability and security.

91. *Connecting Europe at High Speed: National Broadband Strategies (2004). See http://ec.europa.eu/information_society/eeurope/2005/doc/all_about/broadband/com_broadband_en.doc.*

92. *Denise Silber, The Case of eHealth, in: EHEALTH (I. Iakovidis, P. Wilson and J.C. Healy eds.), 2004*

93. *The 'i2010 - A European Information Society for growth and employment' initiative was launched by the European Commission on 1 June 2005 as a framework for addressing the main challenges and developments in the information society and media sectors up to 2010. See http://ec.europa.eu/information_society/eeurope/i2010/index_en.htm.*

The second objective of i2010 is *"world-class performance in research and innovation in ICT"*. It justifies the technological pillars of the Seventh Framework Programme for Research and Technological Development, which include advanced and open communication networks, secure and dependable software, and embedded systems.

The third objective is an Information Society that is inclusive, provides high-quality services and promotes quality-of-life.

In the context of the above, the digital health service, eHealth, is addressed by the eHealth Subgroup of the i2010 Working Group of member-state stakeholders. The Directorate General Information Society and Media of the European Commission issued the document 'Connected Health - Quality and Service for European Citizens' in 2006. As a logical follow-up, the Commission is now preparing together with the member states a call for two macro pilots on trans-national interoperability of digital patient summaries and ePrescribing.

7.2.3 Barriers and challenges

In terms of organisation and governance, the actual situation in the field of healthcare is extremely heterogeneous across Europe. The current state is largely one in which systems are autonomous at the regional level or - most often - even at the level of the individual unit (e.g., hospital), and for security and privacy-protection reasons, health networks are constructed to be as insulated as possible from other networks. As is illustrated in Section 7.3, the variety of approaches to build national or regional infrastructures and services in the healthcare sector is considerable.

A nationwide secure and interoperable infrastructure allowing communication between the various key actors providing healthcare and carrying out health research - a national health data network - has been established in only a few European countries. Some of the reasons for the heterogeneous situation and the lack of health data networks in Europe are:

- non-interoperability of systems for technical, semantic, ontological, linguistic, administrative and/or legal reasons;
- lack of common models and standards for health 'content';
- lack of services needed on the network to provide data security, personal identification, authentication and authorisation.

In addition to these traditional barriers for the use of networks in healthcare, there are challenges related to the use of NREN infrastructure in a national or regional context, should the NRENs want to enter this 'market'. Four such barriers should be mentioned here:

- Depending on the depth of service offered by the NREN, in some countries the NREN may be accused of unfair competition by telecommunications companies and other infrastructure providers, which are hoping that a market will arise for such services. Especially in the case of the EU-15 countries, this should be carefully investigated prior to the start-up of any additional activities.
- The perception that NRENs operate 'open' networks for research communities may cause strong reluctance with companies and organisations involved in healthcare and health research, due to their specific needs for data protection, security, guaranteed service etc.
- There are organisational problems for the health sector in finding the right parties at the NRENs who are willing to sign appropriate Service Level Agreements and commit to the financial risk involved.
- Some NRENs are not allowed to connect organisations, such as hospitals etc., outside their traditional user community in higher education and research[94].

94. *TERENA Compendium of National Research and Education Networks in Europe. See www.terena.org/compendium/.*

7.2.4 Applications drive the need for network infrastructure

Dennis Protti wrote: *"Infrastructure breeds impatience. It is important to note that the provision of infrastructure services is an enabling mechanism. The infrastructure itself will deliver some benefits, but the main outcomes will be achieved by the provision of additional applications and services. As with any infrastructure, information technology infrastructure does not provide direct business performance. Rather it enables other systems that do yield business benefits. IT infrastructure is strikingly similar to other public infrastructures such as roads, hospitals, sewers, schools, etc. They are all long-term and require large investments. They enable business activity by users that would otherwise not be economically feasible."* [95]

This quotation clearly states that the development of infrastructure is nothing but a means for developing more advanced applications and services, which then become enablers for organisational change. The current focus in the literature and in the EU-supported initiatives[96] is a patient-centred approach, where some of the patient data is stored on a citizen card. This approach tends to focus the attention of the public on the security and privacy issues related to the card and the information stored on it.

However, in actual fact, much network-related information exchange is server-to-server-based and not necessarily initiated as part of direct patient involvement (e.g., image or laboratory data communicated between hospitals). The exchange of this type of data is critical to patient care through better and faster availability of the patient data at the point of treatment.

As can be seen in the categories defined by McGinnis[97], complex relationships exist between standards, technology, devices and infrastructure, which all must interact in order to deliver valuable applications. According to his study of health informatics, it includes eleven categories:

- clinical data management;
- decision support systems;
- technical and hardware issues;
- technical network issues;
- database structures and constraints;
- autonomous smart devices;
- standards for the language of communication between healthcare providers;
- data exchange standards language for communication between healthcare devices;
- legal and ethical considerations;
- telemedicine;
- patient-centred computing.

From this viewpoint, the basic network infrastructure is the fundamental link that allows data exchange between healthcare actors to take place using interoperable applications based on the use of standards for the data types involved.

7.2.5 Applications on the network

The network needs to be in place before applications for the exchange of health-related personal data can be implemented and used. Looking at most of the current network use in the health sector, there is not a huge need for bandwidth, compared to the current offerings of research networks, and for most operational applications it would be sufficient to have a bandwidth capacity of

95. *Dennis Protti, Implementing Information For Health: Even More Challenging Than Expected?, A white paper prepared for Dr. Peter Drury, Head, Information Policy Unit Department of Health, and Dr. Gwyn Thomas, Acting Executive Director, NHS Information Authority, 2002*

96. *Connected health, Quality and Safety for European Citizens, Report of the Unit ICT for Health, 2006*

97. *Patrick McGinnis, Scope and Direction of Health Informatics, Aviation, Space and Environmental Medicine Vol. 73, 2002* approximately 20 Mb/s, and in some countries with less developed infrastructure even bandwidths as low as 1-2 Mb/s would be a great improvement.

However, looking at health research and emerging applications, there are some applications and organisational pressures that are pushing to higher bandwidths - without compromising security and reliability. When genetic profiles are involved, some countries even impose more strict privacy and security regulations for the transmission of such data. Emerging applications include, but are not limited to:

- remote high-resolution radiology in which collaborative investigation of radiological images demands that the same image be viewed at two different locations by experts;
- bio-informatics, which is developing rapidly as it attempts to link genomic data to clinical diagnosis and treatment by using both computational and knowledge Grid technologies[98];
- mammography interpretation using large-scale distributed image analysis;
- remote robotic surgery requiring bi-directional high bandwidth and high reliability in networks;
- educational demonstrations of real-time viewing of surgical interventions and guidance from experts not present in the operating theatre;
- home surveillance and interaction technologies, as more emphasis is placed on home care or non-hospitalised care.

7.2.6 Sensitive health data requires secure and reliable networks

No eHealth service can be effective without a reliable, secure infrastructure that allows controlled access to patient and management information, knowledge and transactions[99].

Health information is considered sensitive personal data and when such data is transmitted, the service provider has to prove that adequate measures are taken to maintain appropriate security levels at all times: encryption, access protection, integrity protection etc. This requires the implementation of national and trans-national services for signature encryption and verification, message encryption and decryption services when these are additional or substitute for signature encryption, as well as ontological services where the coding systems at each end are different, as happens when medical data is transferred between countries.

Table 7.1 lists the five major security dimensions: confidentiality, authentication, integrity, non-repudiation and authorisation. In order to create a secure basis for sending confidential medical data between heterogeneous systems across borders, ICT systems must satisfy very stringent requirements in all of these dimensions.

Security areas	Interpretation
Confidentiality	Data is protected from unauthorised disclosure
Authentication	The identity of users and resources is verified
Data integrity	Data is protected against unauthorised modification
Non-repudiation	A party cannot subsequently deny a transaction by proof of ownership, data origin etc.
Authorisation / access control	Users hold defined rights including the granting of access based on access rights

Table 7.1: eHealth security [100] [101]

98. *More information on the potential for healthgrids can be found at http://whitepaper.healthgrid.org.*

99. *Kevin Dean, Connected Health, 2004*

100. *International Telecommunication Union, Security in Telecommunications and Information Technology - an overview of issues and the deployment of existing ITU-T recommendations for secure telecommunications, 2004*

101. *Based on: L. Beolchi and S. Facchinetti, Telemedicine Glossary of concepts, standards, technologies and users (5th ed.), European Commission, 2003*

Confidentiality can be obtained by digital signatures and asymmetric encryption techniques such as Public Key Infrastructure (PKI). However, the challenge for the standardisation bodies is to find a common denominator satisfying security and legal requirements at the same time[102]. It is necessary that the service provider assures the end-to-end transmission and provides an appropriate level of encryption, independent of the PKI infrastructure. That means that what is sent can be received and transmitted without decoding during transit. Transmissions should be timed.

Especially in the field of digital imaging, the service levels necessary for the use of videoconferencing on large secure systems have so far been difficult to meet. Although this experience seems to be shared between the health and the education sector, to the best of our knowledge a satisfactory root-cause analysis has not yet been made.

All these technologies are being tested in pilot/research mode in the health sector, but there are few very large scale implementations in the sector. The gathering of experience with large-scale implementations is the necessary next step to identify scalability issues and develop the technologies used in the pilots to a point where they can help healthcare organisations to achieve significant improvements in patient care and costs.

7.2.7 Opportunities for NRENs

In 2003, the SERENATE study[103] concluded that, apart from a few incidental connections to hospitals (other than university hospitals), no examples were found of national research and education network organisations offering services to the health sector. There are various reasons for this, but concerns about bandwidth, security and confidentiality seemed to be especially important. Lack of knowledge within the NRENs of the key applications in the sector may also have limited the opportunities for NRENs to provide the sort of services that the healthcare sector is looking for.

Even though the challenges are significant, a number of NRENs may still want to become engaged as active players in establishing national or regional health data networks. Such a commitment should only be undertaken after a careful analysis of the barriers to entry (including possible legal or political obstacles) by the interested NRENs and the costs involved in overcoming them. Such an analysis necessarily involves an in-depth dialogue with the relevant healthcare and health research stakeholders in the country or region in order to identify which services are of interest and where the NREN would like to position itself in the value-complexity chain.

7.2.8 The pharmaceutical industry

The pharmaceutical industry is probably not an interesting user group for NRENs.

The process of discovering and developing drugs takes place in three clearly identified phases, typically called basic research (or discovery), preclinical development and clinical development.

The goal of the discovery phase is to identify and synthesise chemical entities that are actively affecting an identified target for a disease or affliction. The promising chemical compounds are patented. Wet chemistry assays and laboratory notebooks are the main tools, but recently the volumes of data generated by the analytical instruments have increased enormously, and electronic storage along with it. Typically, this sort of data does not leave the company.

102. *P. Feuerstein, Security needs in telemedicine, Presentation to the ITU Workshop on Standardization in EHealth, Geneva, 23-25 May 2003. See www.itu.int/itudoc/itu-t/workshop/e-health/s5-01.pdf.*
103. *www.terena.org/publications/files/SERENATE-FINAL.pdf*

When an active compound becomes a preclinical drug candidate, the packaging (pill) with the appropriate pharmacokinetic and metabolic properties is developed, and the safety analysis starts with animal testing. Much less data is generated in these activities, and they do not get transmitted widely, except for the part that is required for the regulatory submission - if the drug candidate gets that far.

The clinical phase (with its sub-phases) has data flowing over networks between doctors and laboratories on one side and the pharmaceutical company or the Clinical Research Organisation (CRO) contracted to do the study on the other side. The amount of data is rather limited, and the number of regulatory constraints on the handling of it dominates the issues at this point.

Large multinational pharmaceutical companies typically use closed networks that are only accessible to staff and certain categories of contractors. These networks are used for email, videoconferencing, VoIP, development of submissions and publications, as well as exchange of data between laboratories around the world working on the same compounds or therapeutical areas. The suppliers of the network and associated services have to conform to very stringent requirements as regards service levels and guarantee of service (including financial strength), and must be able to offer services in all the countries where the company operates.

With these constraints, it would seem inconceivable that NRENs could be selected as a supplier by a large pharmaceutical company or its subcontractors. It would not seem to be attractive for an NREN either to enter such a market that would require a completely different operational model.

7.3 Health data networks in Europe: status and overview

7.3.1 Overview

Gathering information about the status of health data networks in Europe has only been possible by combining knowledge from a very diverse set of stakeholders and contacts in the participating countries. The different approaches and state of development in the participating countries has made it necessary to interact with various entities that are not always equipped to deliver information according to a standardised questionnaire. Table 7.2 reflects the diversity and heterogeneity of partners who contributed information.

Health data networks in Europe typically link healthcare institutions via telemedicine and Web-based services to professionals and patients spread over a broader geographic area than could be served without the technology. Most of these networks are regionally organised and there is not really a standard size or a set of general characteristics for this type of network[104].

There are many interesting examples of eHealth in the EU countries, but there are few examples of country-to-country knowledge transfer and dedicated networks for the health sector outside the Nordic countries and the United Kingdom. A reason for this might be related to the focus on national policies that strongly promote health informatics and eHealth.

An analysis of the existing health data networks in Europe suggests classification into four categories:

- **National networks**
  Nordic countries, Austria, Netherlands and the constituent countries of the United Kingdom

104. *Denise Silber, The Case of eHealth, in: EHEALTH (I. Iakovidis, P. Wilson and J.C. Healy eds.), 2004*

Country	Network partner for information	Website
Austria	UMIT	www.umit.at
Belgium	Belgacom	www.belgacom.be
Denmark	MedCom UNI•C	www.medcom.dk www.uni-c.dk
Estonia	e-tervis	www.e-tervis.ee
Finland	National Research and Development Centre for Welfare and Health (STAKES) Hospital District of Helsinki and Uusimaa	www.stakes.fi/EN/index.htm www.hus.fi
Germany	Georg August Universität Göttingen	www.mi.med.uni-goettingen.de
Greece	Foundation for Research and Technology	www.ics.forth.gr
Iceland	Ministry of Health and Social Security	www.stjr.is
Lithuania	Vilnius University Hospital	www.santa.lt
Netherlands	NICTIZ	www.nictiz.nl
Norway	Norsk Helsenett	www.nhn.no
Serbia	Belgrade University Computer Centre	www.rcub.bg.ac.yu
Slovenia	Ministry of Health Infonet	www.gov.si www.infonet.si
Spain • Aragon • Balearic Islands • Catalonia • Andalusia	TB Solutions Aragon Regional Government Balearic Islands Regional Government Generalitat de Catalunya Junta de Andalucia	www.tb-solutions.com www.aragon.es www.caib.es www.gencat.net www.juntadeandalucia.es
Sweden	Carelink	www.carelink.se
United Kingdom • England	NHS England NHS Connecting for Health JANET(UK)	www.nhs.uk www.connectingforhealth.nhs.uk www.ja.net
United Kingdom • Scotland	Scottish Centre of TeleHealth NHS Scotland	www.scot.nhs.uk
United Kingdom • Wales	NHS Wales	www.wales.nhs.uk

Table 7.2: Health data networks

Organisation of the network infrastructure is handled by a government-initiated institution or company. Various network topologies and technical solutions exist, such as the dedicated Health Network N3 in England and Scotland, and Sjunet in Sweden, as well as the solution in Denmark, where standard Internet connections are used with VPN enabled by the Connection Agreement System (CAS), which handles some of the security issues.

- **Regional networks**
  Other EU-15 countries
  The diversity of implementations is tremendous. Some regions in Spain, Italy and Greece have sophisticated autonomous health networks, whereas other and very heterogeneous regions in Europe have at most local solutions between collaborating institutions.

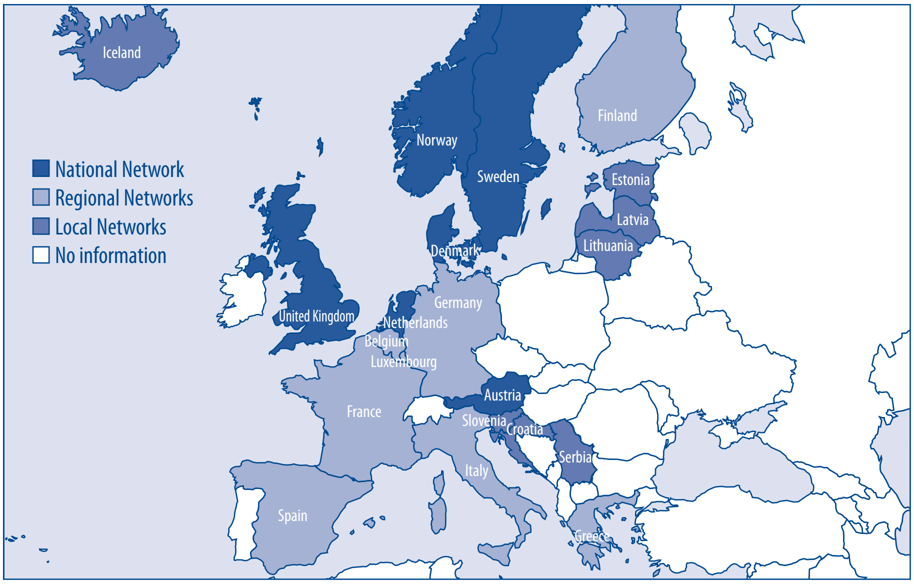

Figure 7.1: Overview of health data networks in Europe

- **Potential leap-froggers**
  New EU Member States
  In general there is a positive political motivation towards the eGovernment initiatives from the European Union and there are good opportunities for obtaining funding for infrastructure development. The network infrastructures in these countries are not yet always well consolidated and it may be within these countries that NRENs have the greatest opportunity to participate in the development of health data networks, especially as image and video transmission are important emerging applications in these countries.

- **Countries that were part of the former Soviet Union**
  The situation in these countries varies considerably. Generally, the systematic and sustainable development of eHealth has not yet been prioritised and funded. However, remote diagnostics and teaching via video are prioritised highly by the healthcare sector in these countries and the NRENs may be able to help significantly by offering relatively high bandwidth at reasonable cost.

7.3.2 National health networks

In a report on eHealth in Europe, it is concluded that the existing national networks seem to provide an appropriate level of co-ordination and service[105].

7.3.2.1 Austria[106]

The situation in Austria is in the process of developing from a regional structure towards a national network.

Since 1996, privately operated report-exchange networks between physicians (and hospitals) have been in existence. In most of the nine Austrian provinces, there are regional networks of the regional hospital trusts and also networks that connect different hospital groups. Since 2005, all 14,000 private practices are connected online (DSL technology in a private network) with the

105. *Denise Silber, The Case of eHealth, in: EHEALTH (I. Iakovidis, P. Wilson and J.C. Healy eds.), 2004*
106. *Information about Austria was mainly provided by Raimund Vogl (UMIT).*

social-insurance data centre via the so-called GIN (Gesundheits Informations Netzwerk). The network is operated by SVC (a social-insurance chip-card company).

In 2007, all hospitals were to be connected as well. Other institutions are planned to be connected via a national 'health ring' - probably a high-availability network operated by the IT service group of the Austrian social insurance (IT-SV).

In 2005, a nationwide chip-card infrastructure was established. About 98% of the Austrian citizens (all within the social insurance system) have an 'ecard' - which is a crypto processor smartcard. This infrastructure allows for a variety of applications - the first established was reimbursement (Krankenscheinersatz - KSE) for the healthcare professionals with contracts with social insurance. Additional applications are to be introduced soon (query for status of insurance contract (Versicherungsdatenabfrageservice - VDAS), approbation of prescriptions of expensive drugs (Arzneimittelbewilligungsservice - ABS), eMedication and ePrescription). The network is also to be used for the planned national electronic health record (ELGA - Elektronische Gesundheitsakte).

The future eHealth interconnects for hospitals will be provided by the four telecommunications companies (Telekom Austria, UPC, UTA, inode). All connected hospitals will have unique, public IP addresses that will enable them to do peer-to-peer communication through this health network (which will basically be MPLS-based). For hospitals they will offer xDSL 2Mb/s symmetric (with guarantee of 98% availability) or leased lines (guarantee of 99.5 % availability).

IT-SV has a nationwide corporate network with 1-Gb/s links and 18 regional access points and will offer this also for hospitals willing to connect.

Currently, the Austrian research and education network (ACOnet) is hardly used for health-related applications. Utilisation for eLearning applications, teleconferencing and video broadcasts etc. could be very beneficial for research and for the increasingly important field of continuous medical education. Security aspects are a key issue whenever patient-related data is transmitted. A connection between the research network infrastructure and the infrastructure for eHealth, which was described above, would be needed. Connection to the GIN could be made through the peering point operated by SVC and the board of physicians in Austria allowing access to the GIN for third parties.

7.3.2.2 Denmark [107]

The concept of the Danish health data net was realised in 2001 by MedCom, which is a co-operative venture between authorities, organisations and private firms linked to the Danish healthcare sector. One of the challenges at that time was to find a way to handle the increasing administration of connecting the many small parts of the healthcare sector, each with its own firewalls and specific ways of connecting its closed network to the closed networks of every other entity.

UNI•C, the NREN operator, did a preliminary technical study of the connection of the existing data net within the health sector. This resulted in a pilot project with the objective of establishing an Internet-based health data network where the stakeholders use existing connections to the Internet, as well as existing routers and VPN concentrators. The network has been in regular operation since February 2003.

The health data net consists of a central node through which all traffic is routed. Thus, to be connected to the health data net, stakeholders must establish a VPN connection from their own 'secure' nets

107. *Information about Denmark was mainly provided by Henrik Søndergaard (UNI•C) and Christina Wanscher (MedCom).*

to the central node. A very important security function in the health data net is the access control between the individual systems of the connected institutions. This is performed by a central unit in the node. The precondition is that each connection is treated as a virtual interface in the central unit, so each individual connection can have filter rules attached to it.

The administration of access rights is handled by an advanced Web-based Connection Agreement System (CAS), which enables the data provider (service) and the data user (client) to indicate which service (IP address) may be accessed by which clients (IP addresses) and by which protocols (port numbers). After an agreement has been concluded in the Web-based agreement system, it is forwarded electronically to both the data provider and the data user for acceptance in CAS before the connection is opened. The bandwidth capacity of the system varies according to the general Internet connection at the sites to the central hub. By mid 2007, 55 VPN connections had been established and approximately 1,250 bilateral agreements had been made regarding data exchange; the security regime is IPsec.

Funding of the network is handled via an elaborate three-stage system of payments, where the users contribute according to size and use of the network.

7.3.2.3 England [108]

The National Health Service (NHS) organisation 'Connecting for Health' procured the national health network in England on behalf of the Department of Health. It is called N3 and is provided by British Telecom using their national infrastructure.

The contract was for 18,000 connections to be complete by March 2007. This was achieved early and the number of connections was just under 19,000 by mid 2007. The main focus is on the connection of hospitals and general practitioners. By mid 2007, connections were being extended to pharmacies in support of the implementation of the electronic transfer of prescriptions. Municipalities (homecare and social care) can and do get N3 connections on request to support joint work with healthcare, but in general they are on Local Authority networks for most of their work.

In general, universities are not connected to the healthcare network but to JANET, the national research and education network provided by JANET(UK). There are some local initiatives to provide local links between the healthcare network and universities, and a gateway between N3 and JANET was implemented by mid 2007. There is a big push to increase support for health research; in practice this involves NHS and university researchers working collaboratively in virtual research groups. The systems need to support this, but at present there is little interoperability between the NHS and universities.

The national healthcare network, N3, is funded centrally by the Department of Health to the degree necessary to achieve the national strategy for clinical applications using nationally procured solutions. Requirements that are over and above that level have to be funded by the local NHS organisations.

N3 has been described as one of the largest VPNs in Europe, i.e., N3 is run as a VPN across British Telecom's MPLS network. There are fixed connections to N3, although these need not necessarily be provided directly by British Telecom - the contract is with British Telecom to provide the network using subcontracted links if and when sensible. However, British Telecom is responsible for achieving the performance standards in the Service Level Agreement.

108. *Information about England was mainly provided by Malcolm Teague (JANET(UK)).*

All NHS hospitals and over 90% of general practitioners are connected. The bandwidth is determined by calculated need, given the number of users and the requirement for the national strategic applications, plus local top-up if necessary. Large teaching hospitals are typically connected at 100 Mb/s; general practitioners' practices may be connected at 2 Mb/s.

There is a 'Statement of Compliance' process overseen by the Information Governance Team at NHS 'Connecting for Health'. Organisations requiring a connection to N3 have to sign a confirmation that the security standards etc. set out in an Information Governance toolkit are being met. This self-assessment is annual, with a right for central audits to be undertaken.

7.3.2.4 Scotland [109]

NHS Scotland has entered into the N3 contract that was set up by the NHS organisation 'Connecting for Health', which procured the national health network in England on behalf of the Department of Health.

There are over 2,000 sites directly connected, including all general practitioners, community pharmacists and most hospital sites. The remaining hospital sites were to be connected by March 2008. A programme was started in 2007 to connect 900 dental practices to N3 before the end of the year.

The Scottish Executive Health Department (SEHD) has developed the NHS Scotland eHealth strategy and NHS National Services Scotland is responsible for its delivery. The national healthcare network, N3, is funded centrally by the SEHD to the degree necessary to achieve the national strategy for clinical applications using national procured solutions. Requirements that are over and above this level are funded by the local NHS Boards. There are five Community of Interest Networks (COINs) operated by local NHS Boards to national standards, connecting around 200 sites including health centres and small and medium-sized hospital sites.

Bandwidth is determined by calculated need, given the number of users and the requirement for the national strategic applications, plus local top-up if necessary. Large teaching hospitals are typically connected at 100 Mb/s; general practitioners' practices may have bandwidth from 512 kb/s to 2 Mb/s depending on the number of users. Typically, health centres are provided with 2-10 Mb/s. Pharmacists get 256 kb/s for their single connected computer. The majority of small sites are connected to the core N3 using ADSL business services, with larger sites connected via private circuits or Ethernet. Secure VPN access into N3 for remote/mobile workers based on two-level authentication is provided.

7.3.2.5 Wales [110]

The NHS in Wales has a national private network, the core of which is an MPLS-based VPN network provided by British Telecom. The network has been in use for approximately 6-7 years and is known as the Digital All-Wales Network (dawn$_2$)

Connected to the network are hospitals, clinics and general practitioners' practices. In total there are approximately 800 direct connections on the network. In addition, there is a direct connection onto N3 (England's NHS Network), so that NHS Wales can communicate easily with their users and sites. Community pharmacies were being connected in 2007, but they would be connected via N3. Suppliers can connect either via N3 or via a connection onto dawn$_2$. Local organisations (e.g., hospital trusts) often have their own 'local' wide-area networks, which in turn connect to dawn$_2$.

109. *Information about Scotland was mainly provided by Dave Anderson (NHS Scotland).*

110. *Information about Wales was mainly provided by Carwyn Lloyd-Jones (Informing HealthCare, NHS Wales).*

General practitioners' connections to dawn$_2$ are funded nationally. Other connections are funded by the various NHS Wales organisations.

Access to national and regional clinical applications, as well as Internet access, email etc. are some of the services offered on the network. It is QoS-enabled and supports a national videoconferencing solution (currently 210 endpoints) used for tele-medicine and various meetings. In addition, VoIP is supported on dawn$_2$ and is used by various local organisations.

The network supports all IP protocols and dawn$_2$ has fixed (guaranteed, symmetric) connections. Access circuit speeds in use are 256 kb/s, 2 Mb/s, 8 Mb/s, 34 Mb/s and 155 Mb/s. Asymmetric connections (ADSL) are also available. Download speeds are 256 kb/s, 512 kb/s, 1 Mb/s and 2 Mb/s. Uplink speeds are 256 kb/s.

All general practitioners have a direct connection at 256 kb/s (or better). Sites that support several general practitioners sometimes have 2-Mb/s connections. Most hospitals connect at 2, 8 or 34 Mb/s. The fastest connection is into Health Solution Wales. They are the NHS Wales organisation that manages the link from dawn$_2$ to N3 and the connection to the Internet.

In 2007, there was a procurement for a new national network that will support all public-sector organisations in Wales. It is proposed that this will be the replacement for dawn$_2$ (subject to meeting necessary criteria). All public sectors will have their own VPN on this infrastructure (e.g., one for health, one for education etc.), but cross-organisation communication can be enabled if required. This project is known as the Public Sector Broadband Aggregation project (PSBA).

'Informing HealthCare' has been establishing the performance and availability requirements to support a patient-centric healthcare model and the PSBA project is the likely route to meeting those requirements.

Regarding the security regime, there is a 'Code of Connection' document, which the Chief Executives of all connected organisations have signed. This document is currently under review.

The most significant legislation is the Data Protection Act 1998, which implements the European Directive 95/46/EC (processing of personal data). Principle 7 of the Act requires appropriate security arrangements. There is also the Caldicott framework, which applies specifically to the use of patient-identifiable information. The International Information Security Standard ISO 27001/17799 is used as the standard that the health community works towards, but this is not mandated to full accreditation level (previously BS7799).

The Welsh Assembly Government is responsible for health in Wales and generally communicates policy via 'Welsh Health Circulars'.

7.3.2.6 The Netherlands [111]

The national healthcare information hub (Landelijk Schakelpunt or LSP), which became operational on 31 January 2006, forms the heart of the basic IT infrastructure for the Dutch healthcare sector. It is the 'control tower' that enables and ensures the secure nationwide electronic exchange of patient information. Via the LSP, healthcare practitioners can request up-to-date patient information from the systems used by other hospitals, pharmacies and general practitioners. A well-functioning LSP

111. *Information about the Netherlands was mainly obtained from the NICTIZ website.*

is considered a crucial precondition for the nationwide introduction of the electronic medication record and the e-locum services for general practitioners, the first two chapters of the national electronic patient record.

The communication services developed within the hub organisation are offered to the Dutch healthcare sector (healthcare practitioners, healthcare insurers and patients) The most important service it provides is the 'referral and routing service', through which healthcare practitioners (and other parties as well, including patients, at a later date), can request up-to-date patient information from systems located at other hospitals, pharmacies and general practitioners' practices throughout the Netherlands.

The National IT Institute for Healthcare in the Netherlands (NICTIZ) is the commissioning authority for the LSP. The LSP has been constructed at the request of the Ministry of Health, Welfare and Sport and the healthcare sector as a whole. Following a European tendering procedure, the development and management of the LSP has been delegated to CSC Computer Sciences BV, a private limited company.

The costs of development and management of the hub are funded by the government for the first few years. During this period, healthcare practitioners and institutions who wish to link up to the LSP will be able to do so free-of-charge.

7.3.2.7 Norway [112]

Norwegian Healthnet was founded on 1 October 2004 by combining prior initiatives from regional health enterprises. It was created to answer the need for a secure and coherent arena for electronic interaction and information exchange within the health and care services in Norway between administrative levels and across regional borders. The Norwegian Healthnet contributes to the implementation of national strategies for the health and care sector, and to the realisation of national strategies within the field of ICT.

Norwegian Healthnet delivers the wide-area network that is used for all interactions. It has an accepted security architecture, sufficient load capacity, unified infrastructure end-to-end, redundancy and one shared administration of the network. The infrastructure uses Telenor Nordic Connect MPLS, which scales from 2 Mb/s to 1 Gb/s, delivered as needed.

Connected to the network are: health enterprises (hospitals), general practitioners, specialists, private hospitals, municipal healthcare, laboratories, radiology departments, suppliers, remote support from different suppliers, dentists, pharmacies, registries/databases etc. Funding of the network is provided by the five regions in Norway.

7.3.2.8 Sweden [113]

In 1998, seven county councils initiated a project called Sjunet, which has now become the Swedish healthcare network comprising an infrastructure for communication between hospitals, primary-care centres and home care. It was established by connecting 21 regional healthcare networks, which are administrated and managed by county councils. The regional county councils are responsible for connecting hospitals and primary-care units. There are also a few municipal healthcare networks, but these are directly or indirectly connected to the national healthcare network via the local county councils.

112. *Information about Norway was mainly taken from the website of Norsk Helsenett and a presentation from Morten Celius (Norsk Helsenett).*
113. *Information about Sweden was mainly provided by Lars Johansson (Carelink).*

In its first version, Sjunet was set up as a VPN with 'tunnels' on the Swedish part of the Internet, and was delivered by Telia. The VPN technology guaranteed that information was kept confidential and the network provider guaranteed that the available bandwidth was sufficient for applications and services. Since 2003, Sjunet is based on VLAN technology from TDC Song with built-in redundancy, technically separated from the Internet. The separation from the Internet means better quality of service in terms of bandwidth and in terms of protection against threats, disturbances, hackers, spam and malicious software. The bandwidth is determined by how much access to Sjunet each county council purchases. Normally 20-100 Mb/s is sufficient for most applications.

Sjunet also hosts a wide range of services from national authorities and healthcare service providers and selected vendors. Sjunet allows secure transmission of healthcare data and applications because it is an IP network separate from the Internet.

Since 2001, Carelink, a collaborative organisation for ICT in Swedish healthcare, has been responsible for Sjunet in close co-operation with all the county councils and representatives for the private care providers and local authorities. It has a centralised administration, but distributed architecture and responsibility (many-to-many network). Carelink sends invoices for administration to each connected unit. The operator of Sjunet (TDC Song) charges for communication costs.

7.3.3 Regional health networks

Regional health information networks (RHINs) are widely seen as the natural evolution in the way healthcare is delivered, with a transition from having general practitioners and general hospitals as the main focus of healthcare towards a system with a range of different specialised functions co-operating in the provision of care. A health region is the geographical area where most health services are provided to the inhabitants in the area, and in which area the patient typically receives almost all of the health services he/she needs[114]. The development of regional health network structures is widespread in most of the EU-15 countries and reflects the most common organisational structure of healthcare.

7.3.3.1 Finland [115]

The Finnish national strategy on eHealth focuses on RHINs. In addition to the national strategy there is new legislation on processing digital information in healthcare and social affairs.

Reform in the Finnish health system has involved one or more of three types of organisational developments: regional co-operation among municipalities, integration of primary and secondary care, and outsourcing of services to public or private providers.

Regional co-operation has attracted the most interest, because the Act on Experiments with Seamless Service Chains has provided the legislative foundation and the co-operation has been funded by the Ministry of Social Welfare and Health.

National strategies have created sharable electronic health records by supporting a collection of federated interoperable repositories with regional middleware services. In the Hospital District of Helsinki and Uusimaa, an established RHIN connects fifteen public hospitals, 27 municipalities (primary care) and two private healthcare clinics. There are 5,000 end-users, information from 1.4 million citizens and 12 million links to electronic patient records. Three other hospital districts (Varsinais-Suomi, Satakunta and Pirkanmaa) are regionally sharing healthcare information encompassing some 2,000 end-users within a population of one million inhabitants.

114. *John Oates and Henrik Bjerregaard Jensen (eds.), Building Regional Health Care Networks in Europe, 2000*

115. *Information about Finland was mainly provided by Kari Harno (HUS).*

Migration to a national health information network and centralised eArchive providing a platform that delivers a longitudinal view of a patient's relevant health records is currently underway.

7.3.3.2 France [116]

There is no national healthcare network in France but there are many regional projects connecting hospitals to hospitals or to doctors. They are often quite advanced. We have not seen any projects related to electronic communication of prescriptions from doctors to pharmacies. In France, the difference between regions in terms of population parameters (including dominant illnesses and risk factors) are considerable and many of the regional projects address a particular therapeutic area.

At the national level there is an electronic health card for each person ('carte vitale') in operational use for the reimbursement system of medical expenses by the state insurance ('sécurité sociale').

A major national project is being implemented to give doctors and hospitals involved in the treatment of a person access to all relevant health information, including any other past or present medications and other treatments, the 'dossier médical partagé' (DMP). Currently, the date set for the introduction is sometime in 2008. The DMP is essentially a central database designed for secure access via the Internet. There is no specific 'health network' planned. The person will not be identified by the social security number in the data base in order to protect the privacy of the information better, should there be violations of the other protection mechanisms. This was a 2007 decision by the CNIL, which is the highest authority in France for privacy protection of electronic records.

One of the reasons for the DMP project is the fact that in the French healthcare system it was possible to consult several doctors on the same ailment without any of those doctors getting any information about the treatments prescribed by the others. This can affect quality of care to a significant degree.

The DMP project decided to fund 36 pilot projects with a total budget of 26 million euro. Significantly, only four of the funded projects are national in scope; the rest are regional.

7.3.3.3 Germany [117]

The situation regarding eHealth in Germany today reflects the federal structure and legislation, where a high level of autonomy is given to the individual states. In addition, the stakeholders, e.g., the insurance companies, are partly acting on a state level. Thus many regional approaches have been developed during the last fifteen years; however, only few reached sustainability. Various regional and local initiatives exist, but there was no development of a common infrastructure - except for an administrative patient (memory) card, which was introduced in 1996 on a national basis. The few existing solutions are typically based on close collaborative links between individual clinical centres and physicians' offices.

During the 1990s a centralised concept was prepared in the framework of several EU-funded projects, e.g., TRUSTHEALTH. A first version of an internationally agreed security infrastructure was financed in 2000. However, the results of those projects could not be implemented directly, as no partner could be found among the key stakeholders.

Instead, a major national legal effort was necessary in recent years to force the conservative stakeholders into a massive national project. Since 2002 this has been pursued by the national

116. *Information about France was mainly provided by Norbert Paquel (consultant).*

117. *Information about Germany was obtained from Otto Rienhoff (University of Göttingen) and from a presentation by Florian Prester (RRZE).*

Ministry of Health. The project survived the change of government in 2003 and has gained more and more momentum. However, the details of the security infrastructure are complex and reflect the extreme data-protection sensitivity of many Germans. Originally, the infrastructure should be operational in late 2006; this had to be postponed to 2009.

In the meantime, many details have been researched and solutions found. By 2007, enough details had been specified, so that test regions could focus on specific details.

The project is legally divided in three parts:

- mandatory applications, e.g., administration data, emergency data and ePrescription data;
- medical applications in the strict legal framework of the national system;
- voluntary applications 'besides' the national system, but linked into it and following the legal regulations in the country.

Examples of the last group are projects like the EVA project of the German Hospital Organisation, the Physician-Letter of the industrial organisation VHitG, the EPR-Ruhr in North Rhine Westphalia. This group could probably also use the well-known Danish solutions mentioned above.

In this context a couple of points are of major interest:

- There is a new and much better understanding between the German Ministry of Health and the 'ICT for Health' office at the European Commission in Brussels. They worked together in designing the eHealth Conference in April 2007 in Berlin, and that might be a good ground for European projects that bridge the EU project approaches and the German national approach.
- The German 'Telematics Platform for Medical Research Networks' in Berlin is co-operating with the various groups mentioned above and is working on defining a communication solution for its members, including a generic data- and privacy-protection solution, developed together with the privacy officers of the states in Germany.
- Some local initiatives and projects between universities and regional hospitals are very advanced. Examples are the project at the University of Erlangen for the transmission of high-resolution motion pictures in tele-endoscopy using broadband network technology for the transmission of endoscopic video-consultations and the collaboration between TMF and the University of Göttingen exploring appropriate communication forms for virtual medical units. This project is linked back to the Ministry of Health.

7.3.3.4 Greece [118]

The Greek national strategy focuses on regional health information networks, and thirteen RHINs currently are under development. All funding comes from the public administration.

The emphasis in the current national implementation plan is on the interconnection of all healthcare organisations of the National Health System, including hospitals, primary health centres and community health offices. The plan is to connect during a subsequent implementation phase (2008-2013) also private general practitioners, pharmacies and insurance agencies, with the objective to extend the range of services to eReimbursement, ePharmacy etc.

The RHINs are implemented as VPNs. Currently more than 40 VPN connections have been established in the RHIN of Crete. Similar numbers of connected sites exist in the other RHINs. The bandwidth varies, e.g., 2 Mb/s for primary healthcare centres to 10 Mb/s for hospitals. An eHealth platform is

118. *Information about Greece was mainly provided by Manolis Tsinakis (FORTH).*

available in the Region of Crete, which supports synchronous and asynchronous collaboration (tele-radiology, tele-cardiology, tele-emergency care) and videoconferencing.

Having developed the physical layer that interconnects all (public) healthcare organisations at regional level, the most important challenge ahead is the development of a range of user-friendly services to populate the physical network infrastructure and to address the corresponding organisational/deployment challenges, in order to guarantee adoption of the service by healthcare professionals and citizens.

7.3.3.5 Iceland [119]

The ambition is to establish a national health network that will link all healthcare institutions in the country (60 health centres, fifteen small regional hospitals, one teaching hospital and one university hospital).

Currently there is a large local network investment at the university hospital in Reykjavik, which is the strongest IT entity within the healthcare sector. It operates as an independent player in healthcare and the building of a new hospital in the coming years calls for heavy investments in IT. The objective is to increase co-operation of the hospital with other organisations. The other hospitals and health centres are much smaller organisations with a substantially weaker infrastructure and less investment in IT. A network for communication between organisations is being established providing a path for ePrescriptions and various other clinical information. In addition, a number of private specialists are linked through their own private network.

7.3.3.6 Italy [120]

The extension of universal healthcare coverage to the whole population is a key characteristic of the Italian healthcare system. Mandatory health insurance was established in 1943. This system was replaced in 1978 by the creation of the Italian National Health Service (NHS). The Italian NHS follows a model similar to that developed by the British National Health Service. However, the Italian NHS is more decentralised, because of a recent strong policy of devolution, which shifts power to the regions.

The Italian NHS is structured in three different levels of public authority: the central government, the regions, and the local healthcare agencies (LHAs). As the main organisation of the NHS, the Ministry of Health is responsible for national health planning, including general aims and annual financial resources to be spent on health, and for rules about the commercialisation of drugs and medical equipment in accordance with the EU regulations.

The LHAs form the basic elements of the Italian NHS. In 1998, there were 196 LHAs in Italy (a number that is continuously changing) providing healthcare services to the population. Each LHA is financed from its region under a global budget with a weighted capitation system. In addition, there were 98 public hospitals qualified as 'hospital trusts' in 2000. Hospital trusts work as independent providers of health services and have the same level of administrative responsibility as LHAs.

Information regarding the development of network infrastructure was not available for this study. Anecdotal evidence indicates that it is a very heterogeneous set-up with great differences in availability of IT infrastructure in the various regions.

119. *Information about Iceland was mainly obtained from the website of the Ministry of Health and Social Security.*
120. *Information about Italy was mainly provided by Tine Stroemsnes (Cisco Systems).*

7.3.3.7 Spain [121]

The National Health System is made up of both the State and the Autonomous Community Health Departments (seventeen self-governing regional communities) and covers all the health functions and services for which the public authorities are legally responsible.

The Spanish Constitution of 1978 established a territorial structure that allowed devolution of responsibility in the area of health to the Autonomous Communities. As a result, through their respective Autonomy Statutes, all the Autonomous Communities have gradually taken on such responsibilities. The devolution of healthcare responsibility from the National Health Institute (INSALUD) began in 1981 and was completed in 2002, with the Central State Administration keeping the responsibility for health management in the Autonomous Cities of Ceuta and Melilla, through the National Institute for Health Management (INGESA).

The Autonomous Communities now hold responsibility for health planning, public health and healthcare. They have therefore taken on the functions and services, goods, rights and obligations relating to such responsibilities, as well as the staff and budgets assigned to them.

Each Autonomous Community has a Regional Health Service, which is the administrative and management body responsible for all the centres, services and facilities in its own Community, whether these are organised by regional or town councils or other intra-Community Administrations.

The autonomous regions have each implemented a regional health information network. The networks in the regions are mainly publicly funded, and normally each region has an intranet structure in place, which connects hospitals, general practitioners, social care and university hospitals. An exception is Catalonia, where there are several internal networks that belong to the institutions in the region. Pharmacies are not connected to the regional networks, but they have their own network through the Pharmaceutical Professional Association.

There are some healthcare agreements between Spanish regions, e.g., the Aragon region has signed healthcare agreements with bordering regions. Some pilots are being put in place connecting services between regions, such as videoconferencing between Barbastro (Aragon) and Lerida (Catalonia). There are discussions between the different regions to set up further connections in the future.

The technical connections are very different in the different regions of Spain.

In the region of Aragon, there is a fibre ring with eight nodes, which each have either fibre, ADSL or UMTS connections and a capacity of either 155 or 622 Mb/s. The security regime is IPsec and security exists both at a logical level (data ciphering) or/and physical level (firewalls etc).

In the region of Catalonia, different kinds of connections are used depending on the needs of the end-users. They include fixed connections, VPNs for connections between external institutions, and wireless connections through mobile devices as for example, GPRS, UMTS, Wi-Fi etc. The capacity and bandwidth varies, depending on the settings at each site and the infrastructure available. The security regime is IPsec; the responsibility for the security at each site lies with the organisation that owns the data, and is managed by the system administrator of each institution. Currently, several actions are planned in order to define an integration model that is flexible, robust, scalable,

121. *Information about Spain was mainly provided by Jose Manuel Aldamiz (Region of Aragon) and Barbara Vallespin (Region of Catalonia).*

sustainable and based on a consensus to obtain results in the mid term. In order to do so, it is necessary to improve the processes, infrastructures, new ways of working and managing the cultural changes inside the organisations. Interoperability between systems is needed to improve data sharing between different levels of healthcare.

7.3.4 Potential leap froggers

Potential leap froggers are countries characterised by a great willingness to implement eHealth initiatives according to the recommendations from the European Union. In addition, they are only to a small extent burdened by existing infrastructure or legislative issues. As so much is still in the process of being developed, this is probably an excellent opportunity for the NRENs to become engaged in the work of establishing health data networks, should they desire to do so.

7.3.4.1 Estonia [122]

The Estonian eHealth Foundation was created by the Ministry of Social Affairs and major hospitals and medical associations. The foundation co-ordinates the development of a nationwide integrated health information system. The main goals are to develop and govern nationwide eHealth projects as well as to co-ordinate the unification of the information systems of Estonian healthcare providers. The technological objective is to improve the availability of databases without endangering their confidentiality and integrity, while still ensuring their accountability.

In collaboration with the Ministry of Social Affairs, the Estonian eHealth Foundation is in charge of three eHealth projects. These projects include the development of an information system for electronic health records, digital registration and digital images. These three main components of the eHealth information system will be the cornerstones of a single system for the use of the dispersed health data of patients. The system will ensure an integral and necessary data set for the treatment of patients and create preconditions for improving the methods of treatment.

The Electronic Health Record (EHR) is a database containing the primary data of the patient, his/her entire health record, information on his/her visits to doctors and other data. The EHR is the most central and voluminous part of the eHealth information system, offering basic functionality for other components of the information system - central exchange of messages, data-storage service, system of rights, security solutions, and the administration of nationwide-used standards. The intention is to use existing infrastructure wherever possible and to implement new infrastructure where the existing one is inadequate.

One of the key elements of the EHR project is X-road [123]. X-road is a secure message-exchange system based on the XML-RPC and SOAP protocols, which is designed to enable secure communication between different parties such as, for example, connections between enterprise databases situated in different geographical locations or communication between a company and its suppliers.

X-Road is currently used for interconnecting Estonian government agencies and databases. By September 2006, X-road had 67 databases providing services, 392 institutions and companies using the services and 687 different services.

Eventually, there will be many more organisations connected with each other using X-Road. All of them must implement all the security protocols required.

122. *Information about Estonia was obtained from websites and from a presentation by Kristiina Rebane (Estonoian eHealth Foundation).*
123. *www.ria.ee/27309*

7.3.4.2 Lithuania [124]

There is no official national healthcare network in Lithuania yet, but there are real efforts to create one with the financial support of EU Structural Funds in projects managed by Vilnius University Hospital.

There are 57 healthcare institutions in the country (university hospitals, regional and municipality hospitals, outpatient clinics and primary-care offices), which were connected in early 2007. An additional sixteen were planned to join the network later in the year.

There is a local network in Vilnius to which all healthcare institutions belonging to Vilnius municipality are connected. Connection to the Internet is paid by the end-user: the healthcare institution. The VPN connections are run by Vilnius University Hospital and are paid by various projects. Later, the Ministry of Health is expected to finance the management of the VPN network.

The largest healthcare institutions in the country are the teaching hospitals; they are connected (at least 100 Mb/s) to the Internet via LITNET, the national research and education network. In Vilnius an optical-fibre network was recently installed connecting the municipal institutions. In addition, Private Internet Service Providers are often used by healthcare institutions.

7.3.4.3 Serbia [125]

In October 2006, the Serbian government adopted a strategy for the development of the eSociety. The Ministry of Health is co-ordinating several working groups that are to establish of an operational eHealth environment.

At present, two networks operate in the health sector:

- The Health Insurance Fund (HIF) network connects around 190 HIF branch offices. Pharmacies use different remote-access technologies to submit their electronic invoices to HIF. The network is completely financed by HIF. The network is a closed, trusted network with IPsec-enabled communication built as MPLS VPNs in the core (between branch offices), Frame Relay, DSL VPN, GPRS in sub-branch offices and Dial VPN, IPsec for external customers (pharmacies and other healthcare institutions). The capacity is between 128 kb/s and 100 Mb/s, depending on the size of the location and available telecommunications services.
- AMRES, the Serbian NREN, connects more then 60 university hospitals to the Internet. It is entirely financed by the Ministry of Science and Environmental Protection [128]. Users do not pay any fee. This network provides all regular Internet services. Some hospitals use closed hospital information systems and applications. The bandwidth capacity of the network is 1 Gb/s, provided via dark fibre.

7.3.4.4 Slovenia [127]

There are two nationwide networks in Slovenia:

- The Governmental Centre for Informatics operates the HKOM network. It is available for all healthcare organisations (hospitals, general practitioners, laboratories, but not pharmacies. The central server is based at the Institute for Public Health. The network is financed by the government. It is a high-capacity and high-security network, where all connections are handled by the Governmental Centre for Informatics. Currently, 25 hospitals, six laboratories, a few institutes and one primary healthcare centre are connected. The bandwidth varies from 1 Mb/s to 100 Mb/s.

124. *Information about Lithuania was provided by Romualdas Kizlaitis (Vilnius University Hospital).*

125. *Information about Serbia was provided by Pavle Vuletić (University of Belgrade).*

126. *Part of the international connectivity is financed from SEEREN2, a project in the EU's Sixth Framework Programme for Research and Technological Development.*

127. *Information about Slovenia was provided by Boštjan Berčič (Infonet).*

- The network of the Health Insurance Institute is used for communication related to the health insurance smartcard and reimbursement. The network is financed by the Health Insurance Institute.

7.4 Foresight: synergies between health and NRENs?

Health research and the health sector in general form a vast and important area of society. It is natural to look at the possible synergies between this area and the NRENs.

From the perspective of an NREN, serving health research could normally be well within the scope of its usual activities. However, there are a number of basic challenges in defining the concepts related to the delivery of health services and exchanging information using Internet-based network technologies (see Section 7.2) and these can make it difficult for NRENs to position themselves in comparison to network service providers that are dedicated to offering value-added services and customisation to the health sector. In general, NRENs are not considered a relevant service provider for healthcare, because it is challenging to find the necessary competence in an NREN organisation that will dedicate its resources to a sector that is considered to be beyond its area of core business.

In reality, the typical NREN only is associated to the health sector by their provision of general Internet connection to some university hospitals. A relevant question at this point would be: Is this enough for the NRENs and is this enough for health research?

7.4.1 Broadening the spectrum of services offered to health research

NRENs typically offer a number of services to their users over and above the basic offering of IP traffic to the Internet.

There are, of course, the simplest technical services, such as DNS, FTP, mail relays, mailing lists and the like, which are used by almost all types of users.

But most added-value services offered by an NREN are more specialised in nature and require some degree of user involvement: eduroam, videoconference infrastructures, Web hosting, collaboration systems, archiving and retrieval facilities etc. Health research may use and benefit from services like these in case the data involved is not traceable to persons, because confidentiality issues are very important. The healthcare sector is a large user of high-volume transmission services, e.g., videoconferencing and image databases, but to date it has been using separate servers and networks for these services.

In the typical case, this means that when a health researcher is located outside of a hospital, he/she will have to have two separate workstations: one on the university network, connected to the NREN and one on a separate line, connecting him to the relevant hospital network, if this is possible. It would be of great benefit to that researcher if some kind of infrastructure is offered that enables him/her to use the NREN for all his/her network traffic while securing the confidentiality of the health data and still preserving the integrity of the hospital network, He/she would only need to have one workstation, one network connection and probably would need less support from the IT people in either organisation.

What extra services will be needed, depends on local conditions, but it could be a working Public-Key Infrastructure, Shibboleth-enabling of various services, AAI initiatives, easy VPN provisioning and set-up, gateways and firewalls between the two networks, or providing lambda network connections for health-specific purposes. Each community of health researchers and the NREN will have to work out jointly which tools will best address their specific challenges.

Providing these extra services would be a natural activity for most NRENs, because there is nothing new about providing special services for special user groups. Just think of radio astronomers, some supercomputing network infrastructures or the Grid people, for whom many NRENs are using a lot of resources to provide services tailored to the needs of these specific user groups.

If the problems are solved of protecting confidential traffic and data while still using the underlying basic network infrastructure for all data transmission, this will provide a number of benefits to the health researcher:

- better network quality because investments will not have to be split over two network infrastructures;
- one primary line of support for all network problems;
- the same services can in many cases be used for both types of traffic because it is the same organisation delivering services for both types of traffic;
- it will probably be much simpler to gain access to more protected services;
- collaboration among researchers and between healthcare and researchers is much simpler to establish.

And from the point of view of the NREN, there are also some benefits, related to economies of scale and providing connectivity and services to a larger community:

- potential traffic volumes in the health sector are unlocked - traffic that used to be kept in separate network infrastructures may now run in the NREN;
- it is possible for the NREN to provide services such as videoconferencing facilities on the health side of the network;
- when central security infrastructures are provided by the NREN for the whole health sector, instead of each organisation solving the problems individually, the security of both sides of the network becomes easier to operate, document, configure, monitor and audit.

Internationally, there are several examples showing that security infrastructures may bring the network traffic of the health sector on the NREN. These can be found in the section of this study listing the status in each country, where the best examples probably are Denmark, where a VPN provisioning system supplied by the NREN has brought some of the network traffic onto the research network, and Finland, where a PKI deployment enables the health sector to use the NREN infrastructure for transmission of almost all types of medical data.

7.4.2 Serving the health sector in general

Once a piece of infrastructure for research purposes is set up, it can normally be used without any problems for other purposes as well. In fact, this was exactly how the Internet itself started. Therefore, once something works for health research, it will often work for healthcare too, without using extra resources.

In the case of the health sector, it is in practice very hard to define where research ends and patient care starts. Therefore, if an effective security infrastructure is created (originally for the benefit of research), there is an opportunity to extend its use to general practitioners, medical laboratories or pharmacies that all take part in the shared care for a patient who also happens to be the research object. And if, for instance, a security infrastructure is set up for research based on scanning images from a group of patients, it creates the possibility of handling other images from the same scanner.

7.5 Points to consider for an NREN wanting to serve health research

The authors of this study recommend that before expanding the activities of an NREN into the health sector, based on the ideas described above, a number of points be considered carefully:

- Mission and strategy of the NREN
  - Are there any barriers for expanding the traffic volume and applications used in the (university) hospitals that are already served by the NREN?
  - Are there any barriers to expanding the user community to district hospitals, surgery clinics, pharmacies, independent laboratories?
  - Is the NREN allowed to expand into this sector?
  - If not, is the NREN allowed to do consultancy work for a private enterprise that wishes to provide a network for the health sector?
- The national/regional situation in the health area
  - Do the local health authorities already operate a network for exchange of confidential data?
  - Who are the natural partners in the health sector for the NREN?
  - Is the health sector ready for co-operation?
- The current needs of the health sector
  - What types of security infrastructure could be relevant: VPNs, PKI, gateways, firewalls, IDSs, log analysers, AAI initiatives?
  - What types of other services are the most relevant to offer centrally for health research and the health sector in general? Video, streaming, archiving, image repositories?
- The role of the NREN in the health sector
  - Which of these services and infrastructures should be offered by the NREN and which should be offered by others?
  - Could the NREN assist the health sector with research, development and consultancy services to get the process started?

All in all, serving health research and the health sector in general has in most countries been a somewhat neglected area for the NRENs, although it ought to be well within the mission of most NRENs. The authors of this study hope to have provided some inspiration as to the importance of doing something more for this vast group of researchers and for this important area of society.

7.6 Summary and principal findings

The overall conclusion is that the NRENs have an opportunity to support health research and the health sector with consultancy and infrastructure services, but it will take some efforts to do this. The key findings are:

1. Most health data networks in Europe are mainly regional. National solutions exist in the Scandinavian countries, as well as in the Netherlands, Austria and the constituent countries of the United Kingdom. Throughout Europe, a large number of advanced regional applications are

using networks to exchange information between hospitals, generalist doctors and specialist doctors.

2. The healthcare sector has significant political and legislative constraints, which means that the situation in a country or region will not change rapidly even when technological development offers opportunities to make changes that would lower costs and provide better care.
3. The sector is application-driven but still rather immature, with a large number of different applications even within one hospital and a relatively low level of interoperability at this stage.
4. Existing operational applications are not, in general, limited by the currently available bandwidth. However, there are emerging applications that require significant bandwidth, such as tele-diagnostics, remote radiology with exchange of high-resolution images and video streaming for the transmission of surgical operations with a view to teaching or monitoring remotely.
5. The NRENs are generally not involved in the healthcare sector. Exceptions are mainly the Scandinavian and Baltic countries, the United Kingdom and Serbia, where the NRENs are involved in a few projects.
6. The pharmaceutical industry and clinical-research organisations generally use closed, rented networks, have relatively little demand for high-speed connections and are very demanding regarding the service levels agreements and guarantees offered by their contractors.

Preliminary conclusions are:

1. The main 'market' for NRENs would seem to be:
   a. providing parts of network security infrastructure for health research and the health sector;
   b. exchanging large-volume information between collaborating hospitals mostly for tele-diagnostics, medical education, clinical research or monitoring of surgical interventions;
   c. running cross-border pilot projects within Europe, federating a number of motivated healthcare actors in a test of scalability to the international level of network capacity improvements.
2. The main strong point of NRENs in the health context is the excellent international high-speed connectivity that they offer at reasonable cost, including to countries outside Europe.
3. The main obstacles for NRENs to get involved in the health sector are probably:
   a. the perception that they would not adequately protect the confidentiality and integrity of the sensitive personal data involved, and their lack of knowledge of the health sector;
   b. the limitations in the guaranteed service levels offered;
   c. the restrictions to serving other sectors that are imposed by the connection policies of some NRENs.

The study that is reported on in this chapter provides an introduction to the health sector and an overview of the status of health data networking in several European countries, and offers an outline regarding the considerations that a typical NREN must make when expanding into health research and the health sector.

8. References

EARNEST	http://www.terena.org/activities/earnest/
GN2	http://www.geant2.net/server/show/nav.749
SERENATE	http://www.serenate.org/
TERENA Compendium	http://www.terena.org/activities/compendium/

9. Acronyms

AA	Authentication and Authorisation
AAI	Authentication and Authorisation Infrastructure
ABS	Arzneimittelbewilligungsservice
ADSL	Asymmetric Digital Subscriber Line
AHSS	Arts, Humanities and Social Sciences
CA	Certification Authority
CAS	Connection Agreement System
CESCA	Centre de Supercomputació de Catalunya
CESSDA	Council of European Social Science Data Archives
CIANT	International Centre for Art and New Technologies
CINES	Centre Informatique National de l'Enseignement Supérieur
CLARIN	Common Language Resources and Technology Infrastructure
CNIL	Commission Nationale de l'Informatique et des Libertés
COIN	Community of Interest Network
CRO	Clinical Research Organisation
DAM-LR	Distributed Access Management for Language Resources
DARIAH	Digital Research Infrastructure for the Arts and Humanities
dawn$_2$	Digital All-Wales Network
DfES	Department for Education and Skills
DMP	Dossier Médical Partagé
DNS	Domain Name System
DSL	Digital Subscriber Line
DVD	Digital Versatile Disc
DVTS	Digital Video Transport System
EARNEST	Education And Research Networking Evolution Study
eduGAIN	Education GÉANT Authorisation Infrastructure
eduroam	Education Roaming
EHR	Electronic Health Record
ELGA	Elektronische Gesundheitsakte
EROHS	European Resource Observatory for the Humanities and the Social
ESFRI	European Strategy Forum on Research Infrastructures
ESS	European Social Survey
EU	European Union
FTP	File Transfer Protocol
Gb/s	Gigabits per second
GÉANT	Gigabit European Academic Network Technology
GIN	Gesundheits Informations Netzwerk
GLORIAD	Global Ring Network for Advanced Applications Development
GN2	Multi-Gigabit European Academic Network
GPRS	General Packet Radio Service
HIF	Health Insurance Fund
ICT	Information and Communication Technologies
IDS	Intrusion Detection System

IP	Internet Protocol
IPsec	IP security
IPv4	IP version 4
IPv6	IP version 6
IRCAM	Institut de Recherche et Coordination Acoustique/Musique
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
IT	Information Technology
ITABC	Istituto per le Tecnologie Applicate ai Beni Culturali
ITU	International Telecommunication Union
ITU-T	ITU - Telecommunication Standardisation Sector
IWB	Interactive Whiteboard
kb/s	kilobits per second
KREONET	Korea Research Environment Open Network
KSE	Krankenscheinersatz
LAIRAH	Log Analysis of Digital Resources in the Arts and Humanities
LAN	Local Area Network
LDAP	Lightweight Directory Access Protocol
LHA	Local Healthcare Agency
LSP	Landelijk Schakelpunt
MARCEL	Multimedia Art Research Centres and Electronic Laboratories
Mb/s	Megabits per second
MPEG	Moving Picture Experts Group
MPLS	Multi Protocol Label Switching
ms	millisecond
NHS	National Health Service
NREN	National Research and Education Network
NREN	National Research and Education Networking organisation
PACS	Picture Archiving and Communications System
PAL	Phase Alternating Line
PC	Personal Computer
PERSEE	Portail de Revues Scientifiques en Sciences Humaines at Sociales
PKI	Public Key Infrastructure
PoP	Point of Presence
PSBA	Public Sector Broadband Aggregation
QoS	Quality of Service
ReACH	Researching e-Science Analysis of Census Holdings
RHIN	Regional Health Information Network
RRZE	Regionales Rechenzentrum Erlangen
SEHD	Scottish Executive Health Department
SERENATE	Study into European Research and Education Networking As Targeted by *e*Europe
SHARE	Survey of Health, Ageing and Retirement in Europe
SME	Small and Medium-sized Enterprise
SOA	Service Oriented Architecture
SPIRE	Secure Personal Institutional and Inter-Institutional Repository Environment
SSL	Secure Sockets Layer
TACAR	TERENA Academic CA Repository

TERENA	Trans-European Research and Education Networking Association
TF-EMC2	Task Force on European Middleware Co-ordination and Collaboration
UK	United Kingdom
UMTS	Universal Mobile Telecommunications System
US	United States
VDAS	Versicherungsdatenabfrageservice
VoIP	Voice over IP
VLAN	Virtual LAN
VPN	Virtual Private Network
Wi-Fi	Wireless Fidelity
XML-RPC	Extensible Markup Language - Remote Procedure Call

Appendix 1

Programme of the EARNEST Workshop on Schools [128]

10 February 2007	
13:30-13:45	Introduction to the workshop and background of the EARNEST study *Andrew Perry - UNI•C (Denmark)*
13:45-14:00	Roundtable introductions and brief discussion: What is the biggest challenge for schools in relation to network connectivity?
14:00-14:20	Why do schools need network connectivity and how do they use it? Views from an ICT co-ordinator. *Russell Ingleby, Westbrook Junior School (England)*
14:20-14:40	What are the infrastructure and service needs of schools? *Marco Neves - Centro de Competência Entre Mar e Serra (Portugal)*
14:40-15:00	Why do schools need network connectivity and how do they use it? Views from Slovenian schools. *Milan Podbršcek, Tehnicni šolski center Nova Gorica (Slovenia), Ivan Kolenko, Poslovno-ekonomska šola (Slovenia) and Krešimir Tomas, Gimnazija Novo mesto (Slovenia)*
15:30-15:45	Questions and discussions - follow up of issues raised at round table
15:45-16:15	What technical support do schools need? *Richard Galvin, European School, Mol (Belgium)*
16:15-16:45	What support and services can NRENs offer to schools? *Tomi Dolenc, ARNES (Slovenia)*
16:45-17:00	Questions
17:00-18:00	Roundtable discussion on specific themes
11 February 2007	
09:30-09:50	Networks and learning - what's the connection?: Northern Ireland - a whole country case study *John Anderson, Department for Education (Northern Ireland)*
09:50-10:10	"Let their voice be heard" - learner led change in services for schools *Doug Dickinson, ICT consultant (UK)*
10:10-10:20	Questions
10:20-10:40	What impact has network connectivity had on my school? *Mario Marinho - Agrupamento de escolas de Avelar (Portugal)*
10:40-11:00	What has changed for our school with the development of networking? Thoughts from Slovenia *Milan Podbršcek, Tehnicni šolski center Nova Gorica (Slovenia) and Krešimir Tomas, Gimnazija Novo mesto (Slovenia)*
11:00-11:10	Questions
11:10-11:55	Continuation of discussion from day-one and roundtable discussion on selected themes
11:55-12:00	Feedback and conclusions

128. *More information about the workshop, including the slides of the presentations, can be found at www.terena.org/activities/earnest/ws-schools/.*

Participants in the EARNEST Workshop on Schools

Presenters:

John Anderson, Department for Education (Northern Ireland)
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Tomi Dolenc, ARNES (Slovenia)
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Appendix 2

Persons interviewed for the study on the arts, humanities and social sciences

Ann Doyle, Internet2 Manager for Arts and Humanities Initiatives, United States

Don Foresta, International Co-ordinator of the MARCEL Project and Senior Research Fellow at the London School of Economics, United Kingdom

Laurent Ghys, Responsable Informatique, and Andrew Gerzso, Directeur Médiations Recherche/Création at IRCAM , France

Peter Gietz, CEO DAASI International GmbH and TextGrid project partner, Germany

Georges-Albert Kisfaludi, Professeur des enseignements artistiques, responsable du "Collège Numérique", de l'Atelier de recherche et Création "scènes virtuelles" et coordinateur du Master Multimedia, à l'ERBAN - Ecole Régionale des Beaux Arts de Nantes, France et Consultant pédagogie et techniques multimedia, chargé de mission de services et établissements sous tutelle du Ministère de la Culture et des collectivité territoriales, France

Bernard Rapacchi, directeur adjoint de la Maison des Sciences de l'Homme-Alpes, CNRS, France

Francoise Thibault, Ministère de l'Enseignement supérieur et de la Recherche, France

Martine Tual and Marc Batllo, CINES, France

Paul Wouters, Programme Leader and Founding Member, and Sally Wyatt, Senior Research Fellow, Virtual Knowledge Studio for the Humanities and Social Sciences, Netherlands